Oxfordshire: a trailblazer for the UK economy

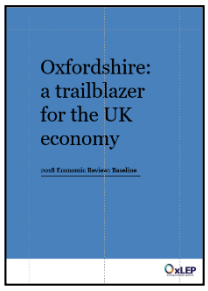
2018 Future State Assessment

DECEMBER 2018

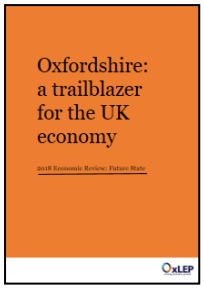
OxLEP
driving economic growth

A GUIDE TO THE SUITE OF OXFORDSHIRE INDUSTRIAL STRATEGY DOCUMENTS

We have produced three reports which, taken together, set an understanding of the current Oxfordshire economy, its future growth potential and how we can work together to deliver the opportunities we have identified. Further information about what you can expect from each report is set out below.



The **Baseline Economic Review** is an objective assessment of Oxfordshire's economic performance to date. It explores how Oxfordshire has performed relative to the UK as a whole, as well as the relative performance of each district authority and different types of businesses and sectors within the county. This report provides detailed economic and spatial analysis that has helped us to shape and prioritise future plans for inclusive growth, productivity improvements and place-based developments, which are set out in the Oxfordshire Industrial Strategy.



The **Future State Assessment** sets out what Oxfordshire has the potential to achieve. It introduces the context for why we are aspiring to be a top three global innovation ecosystem and what this means for Oxfordshire, as well as detail on the key industries in which Oxfordshire can be globally competitive. It details an ambitious economic growth agenda for Oxfordshire, along with the counterfactual 'do nothing' scenario that discusses the risks we face if we do not initiate a step change in growth. Finally this report sets out a spatial vision for Oxfordshire, to ensure that growth in Oxfordshire is achievable and sustainable.

The Oxfordshire Industrial Strategy is the overall plan to deliver inclusive growth across Oxfordshire, drive productivity and innovation, and generate additional growth for the UK. Our vision is to be a top three global innovation ecosystem by 2040: the Oxfordshire Industrial Strategy includes a number of priority interventions to achieve this. It builds on the Strategic Economic Plan whilst setting priorities for the longer term. Its audience will be HM Government, who has commissioned Oxfordshire Local Enterprise Partnership to develop the Oxfordshire Industrial Strategy. It is also designed to help investors, businesses and local communities understand more about our ambitions and how we seek to drive transformative growth in Oxfordshire from now to 2040.

The Investment Prospectus will underpin the Oxfordshire Industrial Strategy. It will take forward the policy interventions central to the Oxfordshire Industrial Strategy, setting out in more detail how we will work with partners across Oxfordshire, the UK and internationally to deliver them. It will also act as an investment prospectus for Oxfordshire, for both public and private investors to understand how they can invest in Oxfordshire to enable us to achieve our growth potential.

Contents

1. INTRODUCTION TO THE ECONOMIC REVIEW: FUTURE STATE

1.1 INTRODUCTION

As identified in the Baseline Economic Review, Oxfordshire is one of the strongest economies in the UK. We are a net contributor to the UK exchequer, currently contributing £23 billion Gross Value Added (GVA) in real terms each year.[1] We are also steadily growing, with average 3.9% growth year-on-year in nominal terms since 2006.[2] We have a highly productive economy – on a per-head basis the output of our workers is in the top 20% of English regions.[3] Oxfordshire continues to perform well in key indices, with Oxford recently identified as the highest ranking city in the UK in PwC's 2018 Good Growth for Cities report, which measures the performance of cities against key economic and wellbeing indicators, such as employment, health, income and skills.[4]

Our economy is founded on a diverse mix of businesses, which we have grouped into two main categories: cornerstone businesses and breakthrough businesses. Cornerstone businesses provide an essential platform for economic growth, through the delivery of critical services and supply chains (for breakthrough businesses), as well as the majority of jobs for people across Oxfordshire. Breakthrough businesses are our innovation-focused businesses in science and transformative technologies, such as space, quantum computing, digital health and connected and autonomous vehicles. The number of businesses working in transformative technologies is increasing by 9% every year, tapping into global markets that are forecast to deliver £181 billion to the UK economy and £1,300 billion to the global economy by 2030.[5] These are the businesses that have the potential to stimulate rapid growth in Oxfordshire economy, transforming cornerstone businesses models through sharing innovation and technology to improve productivity, and generate additional growth for the UK through wider uplift in manufacturing and supply chain opportunities. Both types of businesses are essential for sustainable future growth in Oxfordshire.

Our economy is strong, but we also face a number of economic and spatial challenges that are holding back growth. While our economy is strong, the Baseline Economic Review also identified a number of challenges that we need to address if we are to continue to grow. We have a productivity challenge, with productivity per hour worked in Oxfordshire below the average for the South East. We also have a productivity gap to bridge between our most and least efficient firms. Our physical and digital connectivity is hindering growth, as is housing affordability and the cost of living, which is making Oxfordshire a less attractive place to live for many. This is a critical issue as our economy depends on attracting and retaining the talent our businesses need.

Looking forwards to 2040, we have an opportunity in the Oxfordshire Industrial Strategy to address the challenges that are restricting growth and build on our strengths to unlock our potential. This Future State Assessment therefore looks forwards to the future, setting out our vision for Oxfordshire and what our economy could look like in 2040 if follow an ambitious trajectory of growth for the region.

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[1] Office for National Statistics GVA by NUTS 3 region, 2017
[2] Office for National Statistics GVA by NUTS 3 region and PwC analysis, 2018
[3] Office for National Statistics Population Statistics and Business Count, 2017
[4] PwC, 'Good Growth for Cities 2018', November 2018
[5] Oxfordshire Transformative Technologies Alliance, 'Oxfordshire Science and Innovation Audit', August 2017; Office for National Statistics business count and PwC analysis, 2017

This report sets out our vision to become a top three global innovation ecosystem. The UK needs a dedicated innovation ecosystem if it is to remain globally competitive - all major countries have at least one innovation ecosystem. In this report, we set out some examples of these and how they have become globally successful. This report, along with the Baseline Economic Review, demonstrates that Oxfordshire is the best place in the UK for this innovation ecosystem to be created. We have a distinctively high concentration of science and technology assets that stimulate innovation across the county. Our world-leading industry clusters operate in rapidly growing global markets – we have already created businesses with market values of over a billion dollars. We also generate additional growth throughout the UK both through research collaboration and through services, supply chains and manufacturing opportunities across the country.

If we initiate a step-change in growth to achieve our vision, we have forecast that we can double the Oxfordshire economy by 2040 to be worth £46 billion. This is £9 billion additional GVA than our economic baseline forecasts, and would be driven by a 2% per annum increase in productivity and the creation of 108,000 jobs. We go on to set out how we can ensure this is an achievable and sustainable growth rate for Oxfordshire, including setting out an illustration of spatial concepts for Oxfordshire's development journey.

1.2 SCOPE OF THIS REVIEW

This report has been developed by the Oxfordshire Local Enterprise Partnership (OxLEP). It is the second of two reports which underpin the Oxfordshire Industrial Strategy. Where the Baseline Economic Review is an objective assessment of Oxfordshire's economic performance to date, this review explores Oxfordshire's future.

This report sets out our vision for Oxfordshire: to become a top three global innovation ecosystem. It looks at our industries that have the potential to push Oxfordshire to the forefront of global innovation, and highlights the global competition that we face moving forwards. It focuses on what the future of our economy might look like, first setting out a counterfactual 'do nothing' scenario before outlining an ambitious growth trajectory for Oxfordshire that we need to pursue if we are to achieve our vision and generate growth for the region, and additional growth for the UK.

This review builds on the Economic Baseline Review and underpins the Oxfordshire Industrial Strategy, setting out an ambitious growth trajectory for the region.

Specifically, this review sets out:

- **Our vision:** setting out our vision for the Oxfordshire Industrial Strategy, to position Oxfordshire as a top three global innovation ecosystem, building on the region's world leading science and technology clusters to be a pioneer for the UK for emerging transformative technologies and sectors.
- **Industries and global competitors:** The Baseline Economic Review identified some of the breakthrough sectors that have the ability to drive rapid economic growth in Oxfordshire by capitalising on the new technologies of the twenty first century. In this chapter we look more closely at the key sectors that are stimulating growth in Oxfordshire and generating additional growth in the UK. We also identify our global competitors in each industry, highlighting the need for additional investment to ensure they remain globally competitive.

- **The future of the Oxfordshire economy:** this will look at key trends shaping Oxfordshire's future economy. We then set out two possible future scenarios: a 'do nothing' scenario, and a scenario where Oxfordshire follows an ambitious growth trajectory.
- **Spatial vision for growth:** setting out how we will ensure growth in Oxfordshire is sustainable and best spread across the ecosystem. This will also look at the critical enabling infrastructure that we will need investment in order to deliver this vision.
- **Appendices:** In our appendices we set out more detailed information on the spatial and economic analysis. We also set out a guide that brings together the evidence from across the Baseline Economic Review and this Future State Assessment, setting out how this evidence feeds into the Oxfordshire Industrial Strategy.

2. OUR VISION: A TOP THREE GLOBAL INNOVATION ECOSYSTEM

Oxfordshire will be a top three global innovation ecosystem by 2040, building on our world-leading science and technology clusters to be a pioneer for the UK for emerging transformative technologies and sectors.

2.1 INTRODUCTION

As the Economic Baseline Review outlined, Oxfordshire has one of the strongest economies in the UK. It is home to a dynamic and distinctive business base, with a base of productive cornerstone businesses that underpin growth in the region, and a group of breakthrough businesses that are growing rapidly and forming world-leading science and technology clusters. These businesses and clusters are competing in markets that are global and that expect rapid growth in the future. Oxfordshire is also home to a significant number of national assets, world-class education and research facilities, and a highly skilled talent pool.

Oxfordshire's ambition is now to become a top three global innovation ecosystem by 2040. To achieve this, we need to understand the essential characteristics and drivers of a successful innovation ecosystem. We then need to use this to understand what Oxfordshire must focus on to achieve this vision.

This chapter will set out:

- [2.2] Key findings summarising the chapter
- [2.3] A global innovation ecosystem – what is the definition of an innovation ecosystem and why is this important both for Oxfordshire and the UK?
- [2.4] International case studies of other global innovation ecosystems
- [2.5] The six essential characteristics of a global innovation ecosystem
- [2.6] What does this mean for Oxfordshire?

2.2 KEY FINDINGS

- For Oxfordshire to succeed as an innovation ecosystem, it is important to understand what a successful innovation ecosystem looks and what characteristics enable them to succeed.
- A case-study analysis demonstrates that there are essential characteristics of a successful innovation ecosystem. These are: iconic brand and vision; liveable place; strong financing; commercial culture; keystone assets and talent proposition.
- Oxfordshire already has a number of these characteristics. However, to become a top three global innovation ecosystem and rival its global competitors, Oxfordshire needs to build a growth strategy that takes account of these findings, setting out a strong proposition for all six essential areas. To do this, we need to initiate a step-change in growth through the Oxfordshire Industrial Strategy.

2.3 A GLOBAL INNOVATION ECOSYSTEM

Definition of a global innovation ecosystem

An innovation ecosystem is a complex system of interconnected resources and activities which are necessary for innovation to flourish. In a successful innovation ecosystem, innovations should be able to easily move from discovery through to application and value capture as innovation is commercialised. This process involves a number of actors, including entrepreneurs, researchers, universities, businesses, the investor community, commercial industry, and other technical service providers, such as accountants, designers, contract manufactures, providers of skills training and professional development.[6]

The concept is increasingly influential in policy making, particularly in regards to sustainable economic growth – sustainable growth requires increases in productivity, and a major source of productivity growth in post-industrial economies is innovation. Innovation is also increasingly important as countries face new social and environmental challenges and technological disruptions.

The UK needs a dedicated innovation ecosystem if it is to continue to compete globally.

The UK Government recognises that science and innovation are at the heart of the UK's future success – they are critical to growth in productivity and business investment, our comparative advantages in the global race and our ability to address societal challenges.[7] The UK is a global leader in science and technology, but the world around us continues to race forwards. The UK needs a dedicated innovation ecosystem if it is to maintain and enhance its global position, and deliver increases in productivity and prosperity across the country. This is critical if the UK is to address the productivity challenge at the heart of the UK Industrial Strategy.

The UK needs a dedicated innovation ecosystem if it is to continue to compete globally, embrace technological change and deliver increases in productivity and prosperity across the country. All major countries have at least one innovation ecosystem – for example Silicon Valley and the Research Triangle in the USA; Tel Aviv in Israel; Quantum Valley in Canada; Pangyo Techno Valley near Seoul in South Korea; the National Innovation Demonstration Centre in Beijing, China to name a few. Oxfordshire is best placed to become the UK's dedicated innovation ecosystem, for the reasons outlined in the Baseline Economic Review which is set out in more detail in this report.

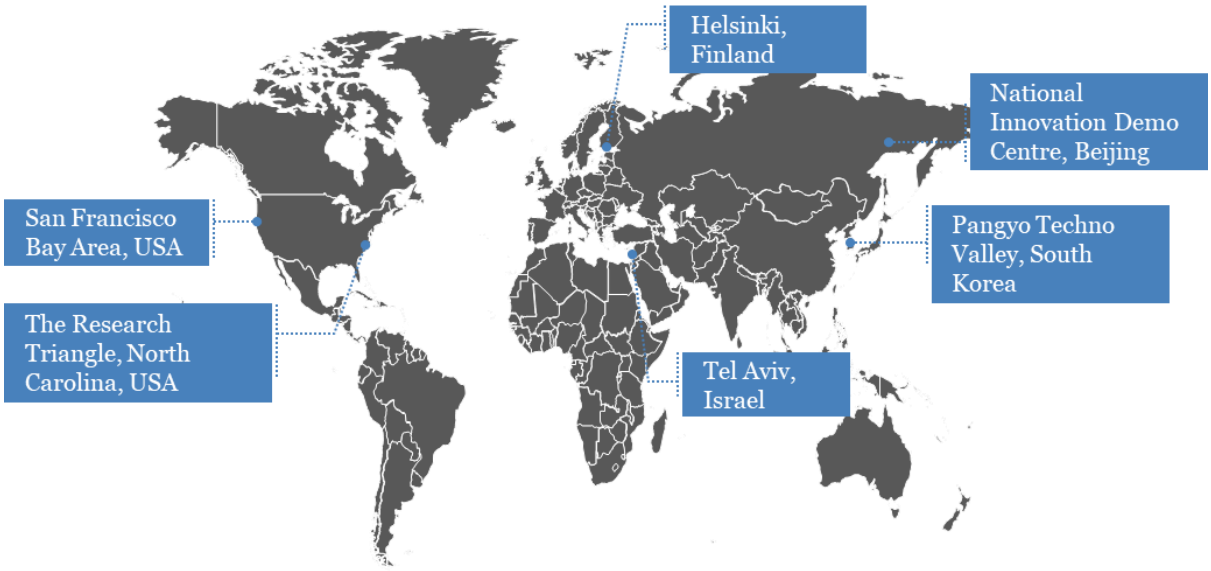
2.4 INTERNATIONAL CASE STUDIES

For Oxfordshire to achieve its ambition, it is important to determine what 'good' looks like for an innovation ecosystem. This is a complicated task – different innovation ecosystems have succeeded with different mixtures of resources and structures, with different sizes, and have distinct characters and strengths.[8] We have therefore chosen to take a qualitative approach supplemented with some contextualised data to understand more about global innovation ecosystems. The purpose of this is to understand the trajectories of different regional innovation ecosystems and the characteristics that enabled them to succeed. Through this, we can draw out the essential characteristics of a top global innovation ecosystem. Applying this lens to Oxfordshire allows us to reflect on the characteristics in which Oxfordshire is already strong and successful. It also reveals some of the challenges Oxfordshire is facing, as it seeks to compete

[6] Jackson, DJ. (2011) 'What is an Innovation Ecosystem?' National Science Foundation, Arlington, VA
[7] Department for Business Innovation & Skills, 'Insights from international benchmarking of the UK science and innovation system', January 2014
[8] Ibid.

with ecosystems that operate across a larger footprint with fewer spatial constraints and different resources. **This analysis is critical as it allows us to start thinking about what policy interventions Oxfordshire might need in order to achieve its ambition.**

We have focused on six case studies of regional innovation ecosystems, chosen for their global spread, international reputation, and the variety and distinctiveness of ways in which they became successful.



The Research Triangle, North Carolina, USA

The Research Triangle is a region in North Carolina with a population of 2.4 million, anchored by North Carolina State University, Duke University and the University of North Carolina. It is one of the oldest and most successful innovation ecosystem models, largely due to the combination of the vision of its founders, sustained private and public investment, and availability of land.

The Research Triangle Park (RTP), founded in 1959, is the central asset of the region. The RTP founders created a not-for-profit venture to fund the park, raising capital to secure the land and attracting investors, partners and talent by highlighting the research strengths of the three surrounding universities. The RTP authority develops, owns and maintains the park, renting and selling land to businesses and institutions. The research institutions in the Triangle have also received considerable funding and support from the federal and state government. North Carolina has the lowest corporate tax rate in the USA, and has been voted number one by Forbes for the Best State to do Business in the USA, attracting more business and investment to the area.

The RTP is now the largest of its kind in the USA, with over 250 businesses and 50,000 people with expertise in fields, such as microelectronics, telecommunications, biotechnology, chemicals, pharmaceuticals and environmental sciences. The Centennial Campus, a 539-hectare site created in the 1980s, houses university, corporate and government facilities and business incubators, encouraging physical interaction, agglomeration and innovation. The universities in the Triangle region produce over 44,000 graduates each year, and the Triangle successfully attracts and retains this talent. With over 50% of people in the region having had a tertiary education, 20% higher than the national average. These findings are largely due to the Triangle being successfully marketed as a region with a mix of rural and urban communities, in close proximity of both mountains and the coast, and full of affordable homes for those seeking world-

class education and jobs. It has its own transport authority – GoTriangle – that operates local services, enhancing the connectivity and liveability of the region.

Key statistics:

- Standard of Living: GDP per capita: $54,290[9]
- Employment and Skills: 4.3% unemployment rate in 2016, and 50% of the working age population has a tertiary education.[10]
- Business and Innovation: 3,000 patents awarded to RTP businesses
- Investment and R&D: Industries invest over $300m in R&D at universities located in the triangle each year.

Helsinki Metropolitan Area, Finland

Helsinki is a newer innovation ecosystem with a strong innovation and start-up culture. Helsinki-based companies excel in listings of the most innovative start-ups in the world, and there have been 250 start-ups in the last decade which together have raised $540.8 million in funding.[11]

Helsinki's innovation ecosystem grew out of its relationship with Nokia, which leveraged investment and developed a strong talent pool in the city drawing from the national 87.9% of people 25+ whom possess a tertiary education. Nokia's closure of operations in Helsinki released a flow of talent that created a flourishing technology, innovation and start-up sector. This relationship has also given Helsinki its distinctive brand, with particular strengths in areas, such as game development. Other significant sectors include software and digital, health technology and environmental and energy technologies.

Strong state support for innovation has also helped Helsinki become a world-leading innovation ecosystem. The city has an innovation unit which is developing a Smart District Living Lab – Smart Kalasamata – to develop and test user-driven open innovation projects. The city has a highly collaborative approach to working with local entrepreneurs, and encourages start-ups to run pilots in Kalasamata. Helsinki's liberal legal frameworks in areas, such as open data and autonomous vehicles have created a strong enabling atmosphere for innovation, giving Helsinki a powerful competitive advantage. This benign innovation policy environment led to Helsinki being one of five 'front runners' in Nesta's 2015 CITIE report[4] which differs from our other case studies, specifically those based in the US. The proactive approach has built a much more sustainable growth model for the city which will enable the city to grow faster in the long run.

Key statistics:

- Standard of living: GDP per capita $48,228 (National average: $43,090)[5]
- Employment & Skills: 10.5% unemployment rate.[12] 87.9% of people nationally hold a tertiary degree in Finland.[5]
- Business and innovation: 1,185 registered start-ups, 250 in the last decade. Home to world leading gaming companies and unicorns, such as Supercell (valued at $8.1bn) and Rovio. Top three for entrepreneurial culture in the Digital City Index.

[9] Statista, retrieved from https://www.statista.com/
[10] United States Census Bureau, retrieved from https://www.census.gov/en.html
[11] European Digital City Index 2016, 'Helsinki', retrieved from https://digitalcityindex.eu/city/13
[12] Helsinki region trends, retrieved from https://www.helsinginseudunsuunnat.fi/en/labour/unemployment/unemployment

- Investment and R&D: European cities and regions of the future study ranked Helsinki as winner in the FDI strategy category for small regions.

Silicon Valley, San Francisco Bay Area, USA

Silicon Valley is in the south of the San Francisco Bay Area of Northern California. The region is a global centre for technology, venture capital and innovation, and is renowned for having nurtured a number of technology giants. The area is home to the headquarters of 39 Fortune 100 businesses, including Apple, Alphabet, Facebook, Intel, Netflix and Tesla, as well as thousands of start-up companies. Its success as an innovation ecosystem is largely due to its unique commercial culture and the distinct liveability of the place.

The success of the Silicon Valley is largely business-driven, not a result of government planning or intervention. The Bay as a whole is a leader in venture capital investments, which has helped it become a leading hub and start-up ecosystem for high-tech innovation. Their region is home to five national laboratories and a number of top-tier universities, giving the region a 54.8% rate of people with a tertiary education, much higher than the national average (30.3%).

Innovation in Silicon Valley is driven by a social network of culture and enterprise that connects business, investors and universities and promotes the flow of information, people and resources across sectors. With a global reputation and attractive climate and lifestyle proposition, the place itself attracts and successfully retains global top talent and business. Silicon Valley is global and multi-cultural, with 36.6% of residents being foreign-born in 2015.[13]

Silicon Valley's global reputation and popularity have caused a rapid increase in population. Insufficient efforts to upgrade transport infrastructure and build new homes has created challenges related to cost of living and congestion.

Key statistics:

- Standard of Living: GDP per capita $126,820 (National average: $57,466)[14]
- Employment & Skills: 2.4% unemployment rate. 54.8% of people in the region have a tertiary education.
- Business and Innovation: Currently home to 83 Unicorns
- Investment and R&D: A huge wave of commercial construction is planned in the area to sustain growth and fuel more investment. Google and other multinational corporations willing to invest in personal transport solutions to remain and grow in the area.

National Innovation Demonstration Zone, Beijing, China

The National Innovation Zone of Zhongguancun in Beijing was the first National Independent Innovation Demonstration Zone in China, officially designated in 2009. It is a model of state-backed commercialisation at scale, with committed development and creation of powerful agglomeration effects. The Zone was created by the State Council to advance innovation and high-tech industries, strengthening scientific and technological innovation and accelerating the development of strategic emerging industries. Its aim is also to transform Beijing into a science

[13] LSCC growth commission, retrieved from http://www.lsccgrowthcommission.org.uk/wp-content/uploads/2016/02/CASE_STUDY_-_Silicon_Valley_San_Francisco.pdf
[14] Statista, retrieved from https://www.statista.com/statistics/183843/gdp-of-the-san-francisco-bay-area/

and technology centre and high-tech industry base with global influence.[15] District government has played an active role in promoting the Zone as a 'high-tech' area.[16]

Over the last decade, the Zone has gathered nearly 20,000 high-tech enterprises and has formed a high-tech industrial cluster. It is spread over 488 km sq. and home to sixteen science parks, two towns and two 'belts' built around industrial clusters. It is the most successful Zone in China: a third of all Chinese companies listed on NASDAQ are from this Zone. The GDP per capita is approximately 150% that of the national average. The Zone also has ten overseas offices to strengthen relationships with overseas Chinese students, foreign institutions and enterprises, including in Silicon Valley, Toronto and London.

Key statistics:

- Standard of Living: GDP per capita $20,298 (National average: $8,123)[17]
- Employment and Skills: There are 85 universities in Beijing but most are situated within the Haidian district.
- Business & Innovation: 20,000 companies in 16 science parks, including several unicorns. Home to 67 state laboratories and 27 national engineering research centres
- Investment and R&D: Receives a third of all venture capital in China.

Tel Aviv, Israel

Tel Aviv has successfully built its brand as a city of innovation over the past three decades, largely due to an ambitious and aggressive commercial approach from national and local government. In particular, the Government of Israel provided major support to build the local venture capital industry in the early 1990s, with a programme consisting of 10 funds of $20 million each to invest in Israel's high-tech sector and attract foreign direct investment. From 2012 to 2016 investment in Tel Aviv reached 3,179 million euros, and ranked fifth among major European cities. The national government has also used financial incentives to attract multinational technology companies and start-ups to settle in the region. The knock-on effect of this has been rapid private investment, with $3.2 billion in venture capital investment over four years.

The innovation ecosystem in Tel Aviv has benefited from military technology spill-overs as well as spill-overs from Intel. Intel is the largest employer in Israel's technology sector, and ex-employees have set up various start-ups, venture capital and mentoring companies.

The municipal government of Tel Aviv has worked to create a distinctive brand attractive to young global talent. High-skilled immigration and talent from local universities form a strong talent pool with almost half of Israel's 25-65 year olds having a tertiary education.

Key statistics:

- Standard of Living: GDP per capita $42,614 (National average: $37,292)[18]

[15] UKSPA, 'Zhongguancun Science Park', retrieved from http://www.ukspa.org.uk/members/zsp
[16] Jenn-Hwan Wang, Tse-Kang Leng, 'Production of space and space of production: high-tech industrial parks in Beijing and Shanghai', *Cross-Currents: East Asian History and Culture Review,* University of Hawai'I Press, 1:1, 2012
[17] China.org.cn, retrieved from China.org.cn
[18] Statista, retrieved from https://www.statista.com/statistics/375240/gross-domestic-product-gdp-in-israel/

- Employment & Skills: 6.9% unemployment[19]
- Business and Innovation: Three Unicorns. Labour productivity 47% above the national average and higher than that of Tokyo.
- Investment and R&D: Ranked the fifth most investable city in Europe and has shown that with $3.2bn of venture capital investment 2012-2016.

Pangyo Techno Valley, Gyeonggi Province, South Korea

Pangyo Techno Valley is an industrial complex in the city of Pangyo in South Korea, located south of Seoul. It is an example of government-led regional innovation, and was opened in 2011 in order to release pressure on Seoul and support the development of new and innovative technologies. Local government also played an active role in developing Pangyo Techno Valley, providing various incentives including real estate and other physical space next to Seoul and the Samsung-centred business ecosystem there.

Pangyo Techno Valley developed rapidly as a centre for IT, biotech and other types of technology. It is now home to over 1,300 companies compared to only 88 in 2011. The South Korean government is continuing to expansion the Valley, developing 'venture campus' sites for start-ups, 'innovation towns' for companies and research institutes, and government organisations to provide support for start-ups, innovative technologies and other industries in the area.

Key statistics:

- Standard of living: GDP per capita $34,858[20]
- Employment & Skills: 4.8% unemployment rate. 80,000 Jobs created in 10 years.[21]
- Business and Innovation: Over 1,300 tech companies including three unicorns primarily in the gaming industry. Several multinational corporations are also based here.
- Investment and R&D: Many multinational corporations are investing in headquarters here, such as Ahnlan, Gabia and ABN.

2.5 THE ESSENTIAL CHARACTERISTICS OF A TOP INNOVATION ECOSYSTEM

These six regional innovation ecosystems are at different stages of development and maturity. They have also all had distinctive trajectories of growth, with different mixtures of resources, structures and key players that have enabled the ecosystem to grow and succeed, again to varying levels.

Despite their differences, looking across these case studies reveal a number of essential characteristics that innovation ecosystems should have in order to succeed. Not all the case

[19] World Population Review, retrieved from http://worldpopulationreview.com/countries/south-korea-population/
[20] Korea's Silicon Valley, retrieved from http://www.jllapsites.com/research/future-koreas-silicon-valley/
[21] International case studies of smart cities, retrieved from https://publications.iadb.org/bitstream/handle/11319/7720/International-Case-Studies-of-Smart-Cities-Pangyo-Republic-of-Korea.pdf?sequence=1

studies included have achieved success in all six areas, illustrating the challenges involved in developing a successful innovation ecosystem.

Framing Oxfordshire against these same characteristics is revealing of Oxfordshire's strengths and weaknesses, and helpful for understanding the areas Oxfordshire should focus on in order to achieve its ambition.

Iconic brand and vision

It is essential for a globally-leading innovation ecosystem to have a distinctive proposition and a strong vision that differentiates itself from other ecosystems in the market. This proposition could be centred on any number of aspects – research excellence as with the Research Triangle; unique climate and lifestyle in Silicon Valley; or a liberal regulatory and open-data environment for high-technology in Helsinki. The visioning aspect can also come from a number of sources, such as the private-sector founders of the Research Triangle Park or the state-led visioning in Pangyo and Beijing.

Oxfordshire needs to think carefully about what distinctive and unique proposition it can make to the world. This must differentiate it from other global innovation ecosystems. Oxfordshire also needs to do more to develop a strong purpose that Oxfordshire's people, businesses, leaders and investors can unite around to pursue growth.

Liveable place

With an increasingly globally-agile working population, being a liveable place is increasingly important for an innovation ecosystem to attract talent, business and investment. Silicon Valley is an area that naturally excels in this characteristic, even though it is currently facing challenges around housing supply and poor transport infrastructure that threaten the Valley's success. The Research Triangle also highlights its location and lifestyle as a key pull for top talent.

Oxfordshire does have a unique and attractive lifestyle, combining science and technology excellence with the historic city, market towns, Areas of Outstanding Natural Beauty and close proximity to London. However, Oxfordshire faces significant challenges relating to living costs and transport. More needs to be done in Oxfordshire, particularly around the science park settings, to make it a liveable place and help solve the housing and infrastructure challenges. Oxfordshire should proactively plan for 'smart city' developments, as in Helsinki, to ensure growth is sustainable, inclusive, and technologically-enabled.

Strong financing

The availability of finance and investment is essential for applied research and development, developing start-ups and spin-outs, and securing the talent and infrastructure necessary for innovation to flourish. Investment can come from various sectors, including public, private and third sector organisations, as well as from both domestic and international sources. The case studies above demonstrate the breadth of financing strategies, such as Silicon Valley's model

build on venture capital, Helsinki's strategy to market the city for foreign direct investment, or the state-funded approach seen in Pangyo and Beijing.

Oxfordshire already does well with specialist finance, home to two funds with a combined value of £1.4 billion. However, Oxfordshire needs to think creatively about its proposition for investors and the type of investments that it is looking for to support its future infrastructure growth and R&D ambitions.

Commercial Culture

Commercial culture covers the broader factors that affect all companies and organisations in the ecosystem, such as tax, regulation, open markets and competition, all of which play a key role in encouraging investment and entrepreneurship. This characteristic also covers the cultures of collaboration and knowledge exchange between different actors that encourages innovation, and the nature of the business population and its drive for and uptake of innovation. Silicon Valley's success is built on its unique business-driven commercial culture. Other regions, such as Helsinki and the Research Triangle, have created enabling commercial cultures through low corporate taxation and liberal regulatory frameworks respectively.

While Oxfordshire is already doing a lot in this area, the region can go further in promoting a culture of collaboration and exchange across the innovation lifecycle and across industries. Oxfordshire benefits from the open markets and competition of the UK economy, but could create better enabling conditions for innovation and commercialisation, for example through regulatory innovation as happens in Helsinki. Oxfordshire also needs to think about how it joins together the driving force of innovative breakthrough industries with its cornerstone base.

Keystone Assets

An innovation ecosystem must be anchored by keystone assets – these can range from physical infrastructure, education institutes, national research facilities and industry clusters, to more intangible knowledge assets such as reputation or links to other national or international systems. The Research Triangle was founded on its three universities. Global businesses, and the clusters that develop with them, also act as keystone assets and anchors – as Nokia originally did in Helsinki and Samsung in Beijing, and as the numerous technology giants do in Silicon Valley.

Oxfordshire performs strongly in this characteristic, home to a globally-renowned university, a number of national assets and several industry-leading clusters and facilities. Oxfordshire has further potential here, with more land available to create new and expand existing assets.

Talent Proposition

Human capital is integral to the innovation ecosystem, as the people that generate and commercialise knowledge and innovation, and attract business and investment. Critical to talent proposition is an ability to train, attract and retain world-class talent, developing skills aligned to business need, and encouraging

entrepreneurial aspiration. Talent proposition also includes those outside the innovation ecosystem that provide essential support to it. Areas with world-leading education institutes, such as the Research Triangle, perform well in this area if they can successfully retain talent.

The talent proposition in Oxfordshire is bolstered by its two universities, who release highly skilled graduates into the Oxfordshire talent pool. Oxfordshire needs to do more work to retain this talent, and attract and retain more international talent. Oxfordshire could also look to improve the way it nurtures and develops the skills of its domestic labour pool, for both high-tech jobs but also for the jobs that support the innovation industries.

	Iconic brand and vision	Liveable place	Strong financing	Commercial culture	Keystone assets	Talent proposition
Research Triangle, North Carolina, USA	✓	✓	✓	✓	✓	✓
Helsinki, Finland	✓	✓	✓	✓		✓
San Francisco Bay Area, California, USA	✓	✓	✓	✓	✓	✓
National innovation demonstration zone, Beijing	✓		✓	✓		✓
Pangyo Techno Valley, Korea	✓		✓	✓		✓
Tel Aviv, Israel	✓	✓	✓			✓

2.6 WHAT DOES THIS MEAN FOR OXFORDSHIRE?

The innovation ecosystems analysed above all have different trajectories of growth, and have succeeded with different mixes of resources, structures, characters and strengths.

Despite these differences, the case study analysis helps us to understand what characteristics an innovation ecosystem needs in order to thrive. Not all the case studies perform strongly in every characteristic, demonstrating the similar challenges that many innovation ecosystems face as well as the strengths they share.

Oxfordshire cannot replicate the examples analysed above, but can learn from them. Oxfordshire is unique, with its own particular strengths and challenges. Oxfordshire already has strengths across a number of these characteristics, but needs to find ways to improve its proposition in all of them. The international comparisons also bring up new questions, such as how Oxfordshire

can compete with innovation ecosystems that are much larger, with fewer spatial constraints and more resources. Developing Oxfordshire's vision as an integral part of the wider Oxford-Milton Keynes-Cambridge Arc will be an important part of addressing this challenge.

Understanding the general drivers of success for an innovation ecosystem helps us to understand where Oxfordshire should focus attention as we look to compete on a world stage, pursue inclusive and sustainable growth and deliver vision for Oxfordshire. This understanding will inform the Oxfordshire Industrial Strategy, which needs to set out how Oxfordshire can build a strong proposition in each of the six essential areas. Through this we can best set out how to position Oxfordshire as a top three global innovation ecosystem by 2040.

How does Oxfordshire perform in the six essential characteristics?

Iconic brand

Oxfordshire needs to strongly set out a distinctive and unique proposition that makes it stand out from its competitors and provides a strong purpose that Oxfordshire's citizens, businesses, leaders and investors can unite around.

Liveable place

Oxfordshire has a unique and attractive lifestyle, but needs to do more in the LIS and with the Oxford-Milton Keynes-Cambridge Arc to solve the critical issues of housing unaffordability and connectivity that are impacting on its ability to attract and retain talent.

Strong financing

Oxfordshire is home to two funds with a combined value of £1.4 billion, but needs to think more creatively about how to attract investors and different types of investment in order to secure the financing it needs.

Commercial culture

Oxfordshire has a strong commercial culture but should look to create better enabling conditions for innovation, commercialisation, and scale-up of businesses.

Keystone assets

Oxfordshire is home to a number of globally-renowned assets, and should look to better use its strengths here and connections with the Oxford-Milton Keynes-Cambridge Arc to better attract talent, business, and investment.

Talent proposition

Oxfordshire needs to do more to attract and retain talent, and to nurture and develop the skills of its domestic labour pool, for both knowledge-intensive jobs and for the critical jobs that support them.

3. OXFORDSHIRE'S FUTURE COMPETITIVENESS

3.1 INTRODUCTION

To become a top three global innovation ecosystem, we need to understand Oxfordshire's global competitiveness. In this section we specifically focus on Oxfordshire's key high-growth industries. These are the industries, some of which were set out in the Baseline Economic Review, which embrace and harness transformative technologies and which have rapidly growing global markets.

For each industry, we set out an overview of the industry including Oxfordshire's key assets and strengths. We then set out some examples of how these industries link across to other areas of the UK either through collaboration or through supply chain and manufacturing opportunities. We then go on to set out Oxfordshire's, and the UK's, global competition in each area to provide an understanding of where Oxfordshire sits globally and how we need to grow to continue to be world-leading in the future.

This chapter sets out the following industries:

- [3.3] Quantum computing
- [3.4] Life sciences and digital health
- [3.5] Space-led data applications
- [3.6] Robotics and Autonomous Systems
- [3.7] Automotive and motorsport
- [3.8] Creative and digital
- [3.9] Cryogenics
- [3.10] Energy

3.2 KEY FINDINGS

- Oxfordshire has world-leading strengths in key industries that are harnessing transformative technologies, have rapidly growing global markets and offer significant opportunities for growth. Oxfordshire's strengths in these industries are centered on our numerous keystone assets, including universities, research institutions, science and technology parks, as well as our strong business base. Oxfordshire's unique strengths and capabilities in these industries are of strategic importance to the UK.
- These industries and the technologies that underpin and enable them are converging – innovation in one sector unlocks new opportunities and potential in another, such as the links between cryogenic technologies and healthcare, space, automotive and energy. The convergence of technologies will unlock new industries and global markets in the future, in which Oxfordshire is best placed to be world leading.
- These industries and technologies, and the future industries that will stem from the convergence between them, will be transformative and shape the world around us.
- Oxfordshire is at the forefront of innovation in these industries, but faces stiff competition from around the globe from other leading innovation ecosystems. If the UK is to continue

to be a world-leader in science and technology innovation, it needs to invest in the Oxfordshire innovation ecosystem to support Oxfordshire's industry clusters to continue to compete internationally.

- Oxfordshire's breakthrough businesses and industry clusters deliver additional benefits for other areas across the UK – including for cornerstone businesses both in Oxfordshire and in the rest of the country. This happens both through collaboration in the development of technologies and innovation, and through the manufacturing and supply chain opportunities that arise from the innovation in Oxfordshire and the high-value jobs that these opportunities create. Developing and investing in Oxfordshire will therefore deliver growth not just for the region but also across the UK.

3.3 QUANTUM COMPUTING

Overview

Quantum computing and associated technologies have the potential to profoundly change the world over the next twenty years. There is a global race to build functioning quantum computers, with significant international security implications as well as rapidly growing global markets. The UK's participation – at scale – is crucial. Oxfordshire is one of the world's largest centres for quantum science.

- The **Networked Quantum Information Technologies Hub (NQIT)** in Oxfordshire is the largest of four hubs in the UK National Quantum Technology Programme, a £270 million investment by the UK government to establish a quantum technology industry in the UK.
- The NQIT Is led by the **University of Oxford,** which is the UK's largest and most diverse centre for quantum research – with 38 separate research teams and around 200 researchers.
- As part of NQIT, the university is leading a consortium of 34 organisations, including nine universities, across the UK to build the first **Q20:20 quantum computer demonstrator** by 2020. The realisation of a practical quantum computer will be one of the biggest scientific and engineering achievements in this century. The Q20:20 engine will bring together the most advanced quantum technological platforms and combine them into a 400-qubit device that will be at the heart of the first generation of a scalable quantum computer.[22]
- It is estimated that Oxford holds active or about-to-start **funding** for quantum research that totals in excess of £20 million. Funders range from public sources such as EPSRC and the EU, through to private investors and technology companies.[23]
- Oxfordshire's excellence in quantum computing stimulates a number of critical **associated technologies and industries**, including machine learning, Artificial Intelligence (AI), cybersecurity, photonics, cryogenics and superconducting devices.
- **Companies in Oxfordshire** produce technologies quantum computing requires. For example, in cryogenics Oxford Instruments has provided NQIT with new dilution refrigeration solutions. Other companies include CryOx and Element 6 at Harwell.

[22] Networked Quantum Information Technologies, received from: http://nqit.ox.ac.uk/index.php/content/about
[23] Oxford Quantum, received from: http://oxfordquantum.org/

Links across the UK

- The NQIT is a collaboration with nine other universities and 34 organisations across the UK. It also supports the other three hubs in the UK National Quantum Technology Programme – including the University of Birmingham-led Quantum Hub in Sensors and Metrology, the Quantum Enhanced Imaging Hub led by the University of Glasgow, and the Quantum Communications Hub led by the University of York.
- Companies across the UK benefit from the UK's research on quantum computing. For example, M-Squared Lasers in Glasgow which manufactures lasers and for which quantum computing is a significant growth area.
- Quantum computers, autonomous vehicles, electronic propulsion and satellite technology are all dependent on the compound semiconductors. Oxfordshire quantum computing industry therefore anticipates close collaboration with the Compound Semiconductor Applications Catapult in South Wales, along with other key facilities in the compound semiconductor cluster. Investing in R&D in these areas will lead to the expansion of the compound semiconductor industry in South Wales, creating economic growth and increased high-value employment in the region, and related industrial benefits elsewhere in the UK.[24]

Markets and Global Competitors

Quantum computing is an emerging technology with the market currently primarily geared towards research rather than applications. However, the growth in the market is accelerating rapidly. The UK has a strong but fragile global position in the race to develop quantum computing technologies, through early advantage and concentrated research excellence. The commercial potential is the transformational potential for established market sectors.

- Across the world, China is hoping to become the leader in Quantum computing, with its National Laboratory for Quantum Information Science set to receive $16 billion in government funding over the next 5 years.[25]
- Other countries have major quantum computing research programmes, including Australiana, Canada, the Netherlands, Singapore, USA and the EU.
- Technology giants like Microsoft, IBM and Google are all racing and investing millions to develop their own approaches to quantum computing. Google recently revealed it had created a 72-qubit computer and are hoping to bring it to the point of quantum supremacy. In 2014 IBM announced a US $3bn research initiative in a range of technologies including quantum computing.

Conclusion

The UK needs to establish a focal point for quantum computing development, where development is faster and more efficient, technology is applied and where interested companies can re-locate. There must also be a national strategic effort to ensure the technology is exploited here in the UK rather than commercialised overseas, so that the UK gains some of the wider industrial and supply chain benefits. Oxfordshire's leading science and innovation capacity, as

[24] Oxfordshire Transformative Technologies Alliance, 'Science and Innovation Audit 2017', August 2017

[25] South China Morning Post, received from: https://www.scmp.com/news/china/economy/article/2140860/china-winning-race-us-develop-quantum-computers

well as its highly conducive business environment and international connectivity (including investment) make it the best place in the UK for further investment in this technology.

3.4 LIFE SCIENCES

Overview

Oxfordshire's life sciences cluster is one of the largest in Europe and is home to world-leading research and teaching and the development of ground-breaking new technologies. The cluster is home to an estimated 180 companies in R&D and more than 150 companies in associated industries. The cluster's excellence is driven by exceptional scientific and research expertise, with over 10,000 employed in scientific R&D and healthcare related manufacturing. The proportion of R&D is over four times the national average.

Oxfordshire has a well-establishing and growing base of innovative companies operating in digital health – an area of considerable strength that benefits from the cross-overs with other local sectors of expertise such as sectors and instrumentation, satellite applications and high performance computing. Oxfordshire's strengths include:

- **The University of Oxford** is ranked No. 1 in the world for clinical, pre-clinical and health, and No. 3 in the world for life sciences.[26] The university allocates more than 60% of total external research income into the **Medicine Division**, and has 23 Nobel Prize winners in medicine and chemistry. It is also home to the Wellcome Trust Centre for Human Genetics and the Molecular Diagnostics centre, a world-leading genomics research capability. **Oxford Brookes University** has considerable research capability in several areas including biomedical imaging, instrumentation and sensors and genomic instability. Together, both universities have an annual student population of 43,610, providing a young dynamic source of new talent for the Oxfordshire life sciences cluster.[27]
- **Major research institutes** in Oxfordshire are at the forefront of life sciences innovation, modern medicine and digital health. These include the Institute of Biomedical Engineering; the Alan Turing Institute for big data and algorithm research; the Big Data Institute; the Diamond Light Source; the ISIS Neutron Scattering facility at Harwell; the BioBank; the Rosalind Franklin Institute at Harwell and the Structural Genomics Consortium.
- **Oxford University Hospitals Trust and Clinical Trials,** which operates four primary hospital sites with comprehensive teaching and research capabilities and strong industry partnerships. The Medical Sciences Division and Oxford University Hospitals NHS Foundation Trust run one of the biggest clinical trials portfolios in the UK.
- Oxfordshire is also home to several major **international companies** in the Life Sciences industry such as Bayer, DaiichiSankyo, Janssen, UCB Pharma, Thermo-Fisher Siemens and Abbott Diabetes Care. Digital health companies include Tessella, based in Abingdon which also has an international presence and is focussed on analytics and software services. It is also home to a number of emerging innovative companies such as Genomics and Exscientia, which is using AI to deliver new drugs.
- Oxfordshire spins out significant numbers of life sciences **start-ups,** including a number of which have become **unicorn** companies with market values of over US $1 billion. Some of the innovative companies spun out of the University include Oxford Biomedica,

[26] The Times World University Rankings, 2019
[27] OxLEP, retrieved from https://www.oxfordshirelep.com/business/key-industries/life-sciences

Brainomix, Oxford Nanopore, Immunocore and Adaptimmune. Oxfordshire is also home to innovative startups in digital health such as Sensyne Health. Start-ups and spin-outs from the university have excellent access to finance through Oxford Sciences Innovation – which has over £600m in funding available to Oxford University startups. Oxford University Innovation is also the number one technology transfer organisation in the country with the highest number of spinouts.

- The Oxfordshire life science cluster has received significant **recent investment through the UK Life Science Sector Deal.** The deal features £1.3 billion of investment from government and industry and aims to use leading-edge technologies such as artificial intelligence (AI) to detect disease and develop new treatments. The UK's business and health secretaries say the investment – which includes up to £79 million from government and around £1 billion from global biopharmaceuticals firm UCB – will 'support healthcare innovation and back businesses to create high-paid, high-quality jobs'. For Oxfordshire, this deal has announced a Vaccines Manufacturing Innovation Centre in Oxford, co-led by the University's Jenner Institute – this is important in opening new opportunities for life sciences **manufacturing** in the county.

Links across the UK

- Oxfordshire's strengths in life sciences and digital health are supported by strong academic connections across the UK to Birmingham, Cambridge and Dundee, as well as the Medicines Discovery Catapult.

Markets and Global Competitors

Life sciences has an extensive global market, as well as significant global competition. The digital health sector is the fastest growing life sciences sector for employment in the UK, but the UK needs to do more to remain globally competitive and preserve its global market share in this area.[28] Oxfordshire has a number of strong key competitors across the globe, we outline a few below:

- Oxfordshire can help the UK compete against areas, such as Boston and San Francisco, the two major life sciences innovation hubs in the USA. The "Life Sciences Corridor" in Boston is home to several start-up companies, hosts world-famous medical campuses such as Harvard Medical School and boasts the presence of many prominent pharmaceutical companies, including Merck, Sanofi, Pfizer and Novartis. Companies operating in the area can take advantage of funding programs offered by the Massachusetts Life Sciences Centre; backed by a ten-year, $1 billion state investment initiative.[29] Likewise, the biotechnology and life sciences sector in San Francisco was responsible for 300,000 jobs and yielded $95 billion in economic activity and almost $30 billion in income in 2017.[30]
- Cambridge in the UK also has a strong life sciences cluster. AstraZeneca recently opened a new state-of-the-art, strategic R&D centre and global corporate headquarters at the heart of the Cambridge Biomedical Campus (CBC). Cambridge is also home to world-leading educational institutions and the Cambridge Science Park, home to over

[28] Oxfordshire Transformative Technologies Alliance, 'Science and Innovation Audit 2017', August 2017.
[29] Life Sciences Corridor, retrieved from https://lifesciencescorridor.com/about-us
[30] San Francisco Center for Economic Development, retrieved from http://sfced.org/why-san-francisco/sectors/life-sciences-biotech/

100 entrepreneurial businesses. The work Oxford and Cambridge are doing to develop the Oxford-Cambridge Arc presents new opportunities for both regions.

Conclusion

Oxfordshire has exceptional scientific and research expertise and is established as one of the leading life sciences clusters in Europe, particularly in the area of digital health which is a fast growing subsector. To remain globally competitive in this sphere, the UK must capitalise on Oxfordshire's life sciences and digital health assets and strengths. In Oxfordshire, the digital health industry is supported by convergences with other technologies in which Oxfordshire has specific strengths, and can be supported further through collaborations with other regions in the UK. Oxfordshire can lead by example in terms of ensuring collaboration between the NHS and industry, to facilitate better care for patients through the adoption of innovative treatments and technologies.

CASE STUDY: OXFORD BIOMEDICA

Oxford BioMedica plc (LSE:OXB) was spun out from the University of Oxford in 1996 and is a leading gene and cell therapy group focused on developing life changing treatments for serious diseases. Oxford BioMedica and its subsidiaries (the "Group") have built a sector leading lentiviral vector delivery platform (LentiVector®), which the Group leverages to develop in vivo and ex vivo products both in-house and with partners. The Group has created a valuable proprietary portfolio of gene and cell therapy product candidates in the areas of oncology, ophthalmology and CNS disorders. The Group has also entered into a number of partnerships, including with Novartis, Bioverativ, Sanofi, Axovant, Orchard Therapeutics, Boehringer Ingelheim/UK Cystic Fibrosis Gene Therapy Consortium/Imperial Innovations and GC LabCell, through which it has long-term economic interests in other potential gene and cell therapy products. Oxford BioMedica is based across several locations in Oxfordshire and employs more than 360 people.

Factors that have enabled growth:

- Access to world-class talent: Oxford BioMedica has grown from 80 people in 2014 to around 425 by the end of 2018, and we are likely to have more than 600 employees by end of 2019. Oxfordshire is a great source of exceptional high quality talent. Along with the fact that Oxford is an attractive business location to our staff this has successfully driven our substantial employee growth.

Factors that have constrained growth:

- Manufacturing, laboratory and office space: Access to readily available facilities in order to build high technology manufacturing, laboratory and office space has been a constraint to our growth. While we have managed to secure additional facilities, the time taken to find the appropriate facility at a reasonable cost and the time taken to gain planning consent has taken far too long and has constrained our growth.
- Infrastructure financial support: In a global competitive environment, where other Companies receive financial support for infrastructure projects, we in our sector do not and this is a huge constraint on our ability to grow our infrastructure in a high risk business area such as Life Sciences.

Figure 3-1 Oxford Biomedica, Oxford

Figure 3-2 Oxford Biomedica, Oxford

3.5 SPACE-LED DATA APPLICATIONS

Overview

The UK Space Gateway at Harwell Campus, Oxfordshire, is the focal point of the UK and European space industry. The cluster is globally renowned, and is home to over 80 organisations and over 2,500 people across Oxfordshire, with national and international research institutions and assets. It has strengths in 'upstream' work, sending satellites into space, and particularly strengths in 'downstream' sub-sectors, which uses technology and data from upstream work in a range of commercial applications. Oxfordshire's strengths and assets include:

- **Harwell Space Cluster:** The Harwell Space Cluster is the gateway to the UK space sector and benefits from the presence of leading public space organisations, including the European Space Agency, RAL Space, Satellite Applications Catapult, Diamond Light Source and UK Space Agency. Harwell is also home to the Science & Technology Facilities Council, with over £2 billion of infrastructure for both public and private research and development. These assets make Harwell home to world-leading R&D expertise and testing facilities that enable the development of new technologies, pushing the UK to the forefront of space research.
- **Global companies and SMEs at Harwell:** Global space companies such as Airbus Defence & Space, Lockheed Martin and Thales Alenia Space have established a presence at Harwell, with activities ranging from the design of propulsion subsystems to satellite navigation systems. These are joined by a range of SMEs from start-ups in the European Space Agency Business Incubation Centre to rapidly growing companies such as Oxford Space Systems, Deimos Space UK, Rezatec and Neptec.
- **Oxford**: The University of Oxford has a wide range of researchers across data science-oriented departments. Likewise, Oxford Brookes University has strengths in Architecture, Built Environment, Computing and Communications Technologies. The City, Oxford Science and Business Parks and Begbroke Science Park contain a range of IT and spin-out businesses and international consultancies with interests in space-related data.
- **Wallingford**: The NERC Centre for Ecology and Hydrology, HR Wallingford, CABI, several environmental consultancies and sections of the Environment Agency, Met Office and British Geological Survey are situated around Wallingford.

Links across the UK

- Oxfordshire's innovation supports new space opportunities across Cornwall, Glasgow and the East Midlands and is integral to upstream satellite innovation from Airbus, Surrey Satellite Technologies Ltd, NPL and the Universities of Surrey and Southampton, with complementary satellite data analytical capability from the University of Portsmouth.

Markets and Global Competitors

- Oxfordshire faces significant competition from other innovation ecosystems across the world. The largest of these is Silicon Valley, which is home to the Silicon Valley Space Centre (SVSC) and NASA-Ames Research Centre. SVSC is focused on integrating the innovative and entrepreneurial practices of Silicon Valley into the burgeoning NewSpace industry which includes practices for business acceleration, incubation and angel level funding.
- In Europe, Toulouse in France is home to Aerospace Valley which brings together 840 companies and over 120,000 employees. 8,500 researchers and scientists are active in innovation across aeronautics, space and embedded systems – representing 45% of the French national R&D potential in the aerospace sector. Aerospace Valley strives to create an ambitious 35,000 - 40,000 new jobs by the horizon year 2025. Likewise, the German Aerospace Centre (abbreviated DLR) is engaged in a wide range of R&D projects in national and international partnerships. DLR has approximately 8,000 employees at 20 locations in Germany with international sites in Brussels, Paris and Washington DC.

Conclusion

The UK space sector was valued at £13.7 billion in 2016 and is estimated to have 6.5% of the global market share.[31] The UK's strategy is to increase this share to 10%. This year the Prosperity from Space strategy also set out a vision for enhanced growth in the UK space sector over the next decade. This aims to double the value of space to wider industrial activities from £250 billion to £500 billion, generate an extra £5 billion in exports and attract £3 billion of inward investment.[32] The Oxfordshire space cluster centered on Harwell will be essential to achieving this and ensuring the UK continues to compete globally against other innovation ecosystems with strong space technology clusters.

Figure 3-3 Reaction Engines, Culham

[31] UK Space Agency Summary Report: Size & Health of the UK Space Industry 2016
[32] UK Government, retrieved from: https://www.gov.uk/government/news/uk-space-industry-sets-out-vision-for-growth

3.6 ROBOTICS AND AUTONOMOUS SYSTEMS

Overview

Oxfordshire is at the heart of Robotics and Autonomous Systems (RAS) activity in the UK, with RACE at Culham Science Centre a key UK centre of excellence. Connected and Autonomous Vehicles (CAV) are a vanguard application of RAS, and will show us how robots can move people and goods more efficiently with far-reaching implications across industries. Oxfordshire is at the forefront of CAV development, and is a leading hub for controlled real world testing. Key strengths in the Oxfordshire ecosystem include (but are not limited to):

- The **Oxford Robotics Institute** kick-started the UK's CAV programme in 2010. Their spin-out **Oxbotica** was created in 2014, and now leads the UK consortium to develop and launch a fleet of driverless vehicles on public roads in 2.5 years. The **DRIVEN** consortium which benefits from a £8.6 million grant awarded by Innovate UK – is an ambitious project that will see a fleet of fully autonomous vehicles being deployed in urban areas and on motorways, culminating in an end-to-end journey from London to Oxford. These vehicles will be operating at Level 4 autonomy – meaning they have the capability of performing all safety-critical driving functions and monitoring roadway conditions for an entire trip, with zero-passenger occupancy. No connected and autonomous vehicle trial at this level of complexity and integration has ever been attempted anywhere in the world.
- **RACE at Culham** is one of the four national CAV testbeds. It operates as one of the UK's only semi-controlled test beds allowing the development of driverless cars, sensor technology and intelligent traffic systems in a safe environment. RACE is working with vehicle testing specialists Millbrook Group to form the Millbrook-Culham Test and Evaluation Environment. This is creating a series of tracks to mimic a range of real-life driving environments where automated vehicles can be put through their paces before going on to public roads.
- Other **companies** in the Oxfordshire CAV cluster include autonomy providers, such as Oxbotica, Arrival/Roborace, StreetDrone, Dynium Robot and FiveAI. The CAV ecosystem also includes companies such as Zeta for smart infrastructure, Nominet which specialises in cyber security, Zipabout for data, Latent Logic for simulation and motorsport companies including Williams.
- **Oxfordshire County Council** is leading projects to innovate in the use of connected and autonomous vehicles in the city of Oxford. The Smart Oxford and MobOx projects involve a range of partners to incorporate these technologies into public transport systems. More detail can be found on this later in the document, in section 5.4, a discussion on living laboratories.

Links across the UK

- Oxfordshire is at the centre of a 70 mile radius CAV testing area, with London and Birmingham at each end. The area includes public testing environments including the 5G innovation centre, and autonomous vehicles trials of Nissan (Cranfield), Oxbotica (Culham), Jaguar Land Rover (Coventry) and Volvo (Drive Me London). These public testing environments bring together a number of partners from across the Oxford – Cambridge Arc and further across the country to collaborate and innovate.

- Figure 3.4 below shows the alignment between the UK CAV Test Bed and the Oxford – Cambridge Expressway. The Oxford - Cambridge Expressway has the potential to become a globally significant Connected Communities Corridor, with both local, national and international significance for developing digital technologies including, living labs, connected and autonomous vehicles.
- The RAS and CAV industries in general will have a marked impact on numerous other sectors of the economy, ranging from transport and logistics to retail, telecommunications and sensing among others. The innovation in Oxfordshire will support the introduction or RAS and CAV technologies into other industries, unlocking growth potential for these industries across the country.

Markets and Global Competitors

- There is growing consensus that most major original equipment manufacturers and a number of technology giants will, over the next 15 years as CAVs increasingly enter the market, dominate the global vehicle market. Traditional OEMs such as Ford, JLR, Volvo, Nissan and Toyota have made substantial announcements on the development of CAVs, alongside investment from 'less traditional players' such as Apple, Google (who have spun its driverless cars project off into a standalone company, Waymo), Intel, Faraday Future and Nvidia.
- There are several global testing hubs, with key competitors including Arizona and Silicon Valley. Arizona has a relatively light regulatory environment around the testing of CAVs which has promoted considerable growth in the last 2.5 years – attracting companies, such as Uber, Lyft and Waymo. Eight of the top-funded independent CAV start-ups are based in Silicon Valley – of which Zoox, Nauto and Velodyne are the largest. Uber, Google and Tesla are also leading on CAV development in Silicon Valley.

Conclusion

By retaining the UK's strong global position in CAV development, revenue to the economy is expected to be at least £51 billion by 2030, with 320,000 new jobs, 5,000 serious accidents avoided and 2,500 lives saved – it is a rapidly growing market that Oxfordshire is uniquely well placed to enter and benefit from.[33] Developing Oxfordshire's RAS industry is essential to growth and to remaining globally significant, competing with areas, such as Silicon Valley, where Uber, Google and Tesla are developing CAVs. Oxfordshire is strongly placed to become a hub for CAV development by acting as a living laboratory for 'controlled real world testing.'

[33] OxLEP, retrieved from https://www.oxfordshirelep.com/business/key-industries/automotive-motorsport

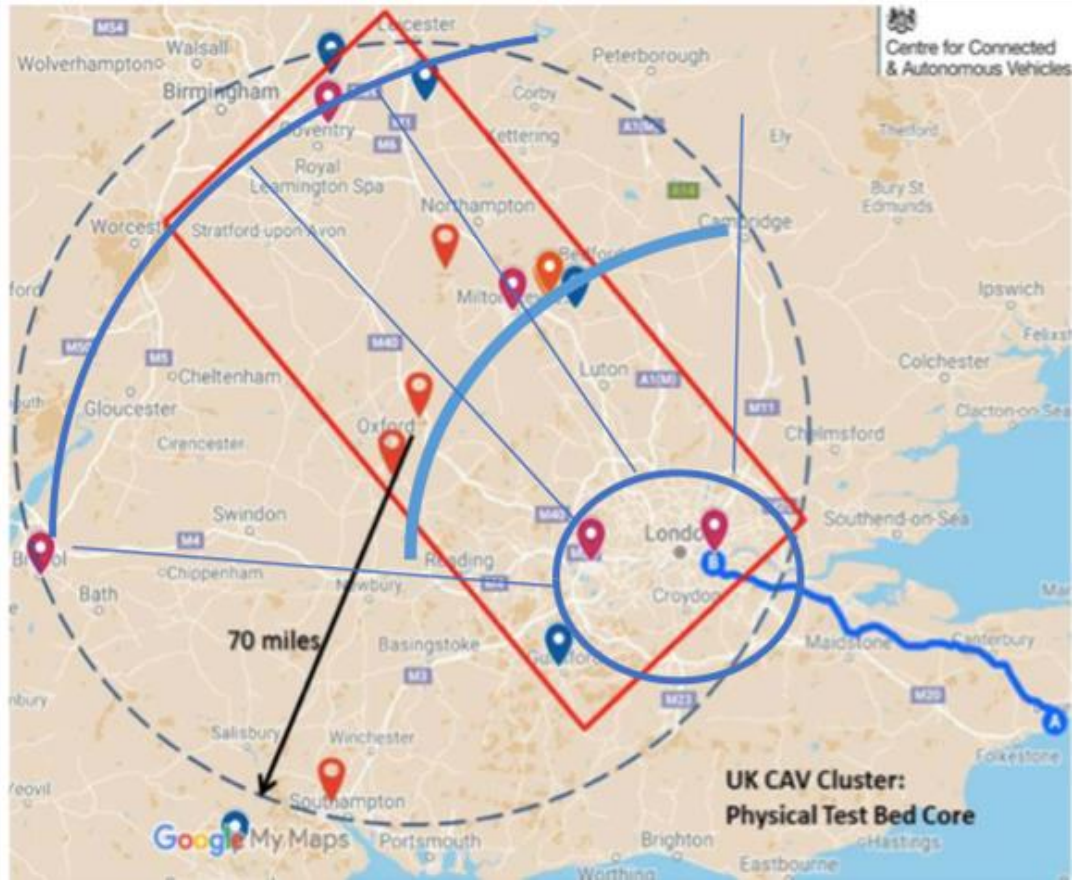


Figure 3-4 Proposed alignment between the UK CAV Test Bed and the Oxford – Cambridge Expressway

3.7 AUTOMOTIVE & MOTORSPORT

Overview

Oxfordshire is a key location on the UK's iconic 'Motorsport Valley', a £6 billion automotive global cluster of high-performance technology, motorsport and advanced engineering companies. Oxfordshire has over 24,000 people employed in manufacturing.[34]

- Oxfordshire is home to a number of **world-leading motorsport names**, including Williams F1 in grove, Renault Sport F1 in Chipping Norton and Prodrive in Didcot. These companies have strong research and development expertise and capabilities, innovating and development new technologies, particularly in electronics, intelligent mobility and lightweight materials – innovation in this industry also supports innovation in a number of Oxfordshire's other high-technology clusters such as space, healthcare and connected and autonomous vehicles.
- The ecosystem also supports a number of **global supply chain companies**, such as SS Tube Technology and Lentus, and the BMW MINI manufacturing plant in Cowley where 2.5 million cars have been produced since the new MINI was launched in 2001, and the new electric MINI is being manufactured. The county's engineering expertise has attracted a growing base of international Tier 1 and Tier 2 suppliers, including French-owned Faurecia which has its automotive seating production plant in Banbury. The

[34] Ibid.

ecoma, part of the $30 billion automotive Magna Group, also has a plant in Banbury, which produces exterior trim systems.

- Oxfordshire has a number of **research strengths**, including in advanced engines and battery technology, where companies like Williams and Prodrive have been pushing Oxfordshire to the forefront of global competition for over a decade.

Links across the UK

- As highlighted above, innovation in automotive and motorsport has adjacencies with other industry clusters in Oxfordshire and across the UK. For example, advanced engineering by Williams F1 focus on taking technologies originally created for motorsport to commercial applications in the defence, aerospace and healthcare sectors. This innovation creates new opportunities across the UK both in manufacturing and supply chains and through spillover effects of innovation.
- Williams is also responsible for the IP and research and development for HyperBat Joint Venture battery manufacturing which is based in Coventry, showing how our energy cluster generates additional growth across the UK

Markets and Global Competitors

- Germany is recognised as a world-leading automotive innovation hub, with the largest concentration of OEM plants in Europe. Germany by some distance is Europe's leading production and sales market. The country's world-class R&D infrastructure, complete industry value chain integration and highly qualified workforce create an internationally peerless automotive environment. Germany is considered the most competitive hub in terms of innovative power – ahead of Japan and South Korea – focusing on sustainable mobility; e-mobility and car connectivity. Oxfordshire competes but also collaborates with motorsport and automotive clusters in Germany. For example Oxfordshire has strong links with Munich, a global hub for engineering with a high concentration of Original Equipment Manufacturers, suppliers, universities, businesses and researchers.
- Attracting talent will be more difficult as the core of automotive research and engineering migrates to software-driven innovation hubs, such as Silicon Valley, Tel Aviv, or Bangalore. Volkswagen Group opened its "innovation campus" in Tel Aviv, which will be the focus of its R&D activities in Israel. BP Ventures also invested $20 million in an Israelei start-up, StoreDot, that develops ultra-fast battery charging technology that can be used for electric vehicles. Hyundai Motor also plans to establish an R&D centre in Israel, which will partner with local start-ups to speed development of next-generation vehicles.

Conclusion

The UK government is committed to the continued success of the UK automotive industry by providing over £1.2 billion to automotive research funds.[35] These cover low-carbon propulsion, lightweight materials and CAVs. The automotive industry in Oxfordshire has the opportunity to deliver further benefits through developing ways to reduce automotive carbon footprint and reduce other environmental and health impacts and risks. Oxfordshire's base of Formula 1 expertise and capabilities, combined with its world class universities make it an ideal location for automotive R&D related activity, that not only leads to innovation within its own cluster but across a number of sectors such as space, defence, healthcare and life sciences.

[35] UK Government, retrieved from invest.great.gov.uk

Figure 3-5 Prodrive, Banbury

Figure 3-6 Williams Formula 1, Grove

3.8 CREATIVE & DIGITAL

Overview

Over 3,000 digital and creative businesses are based in Oxfordshire, with 22,000 people and generating a total of £1.4billion to the UK economy each year.[36] Oxfordshire has strengths in fundamental digital technologies, such as cyber security and data analytics, that enables Oxfordshire to be a leader across other industries from space to bio-tech. Oxfordshire's creative strengths range from animation and digital gaming to digital publishing and media. Specific sub-sectors of considerable strength include:

- **Digital Gaming:** Oxfordshire has a thriving digital gaming scene, with some stand out successes and a thriving start-up scene and networking environment – most notably Natural Motion which sold for $500 million and Rebellion, which has over 300 staff across

[36] OxLEP, retrieved from https://www.oxfordshirelep.com/business/key-industries/creative-digital)

the UK. Rebellion's headquarters are in Osney Mead, Oxford, and the company is also opening a new £78m film studio in Didcot. Oxfordshire is also home to other successful **startups** such as and PlinkArt, a visual search engine, which has now been acquired by Google.

- **Cyber Security**: In Oxfordshire, as well as a nationally recognised cyber security research capability, there is a well-established company base operating in this field, including Sophos, Nominet, RHEA and CQR Consulting. Sophos is a major developer and vendor of computer security software and hardware, and has developed a state of the art "big data" analytics system.
- **Big Data and High Performance Computing**: Oxfordshire has internationally renowned big data and high performance computing capability, particularly around space and life sciences applications. Oxford Instruments, a university spinout, develops data mining tools which can analyse huge sets of data.
- **Digital Publishing**: Oxford University Press is a department of the University of Oxford. It is the largest university press in the world and the second-oldest. Other companies include Elsevier, Taylor & Francis and Pearson Education.

Figure 3-7 Artist's impression of the new Rebellion film studio in Didcot

Links across the UK

- Oxfordshire collaborates within the UK across the Golden Triangle and with other areas such as Bristol where there are strong creative and digital entrepreneurial communities. Oxford Innovation has recently opened an innovation centre in West Belfast, Innovation Factory, to boost start-up development in the region

Global Competitors

- Oxfordshire has both global and national competitors across these various innovation clusters. Globally, Silicon Valley in the USA presents a key competitor where technology and social media giants have disrupted the sector, as Alibaba has done in China. Helsinki has a notably strong digital sector, stemming from its early relationship with

Nokia which leveraged investment and developed a strong talent pool in the city. Nokia's closure of operations released a flow of talent that has created a flourishing technology and digital start-up sector – it is home to over fifty digital start-ups. A digital centre is also being constructed in Hanseatic City State (Hamburg, Germany) and is set to attract large companies and start-ups alike.

- UK based competitors include: Bristol, which has a strong focus on animation and the creative community; London, which attracted an all-time high of £2.99 billion in start-up investment in 2017 (compared with £1.63 billion in 2016); and Brighton, which is home to many local tech entrepreneurs.[37]

Conclusion

Oxfordshire is a key hub of creative and digital innovation, and has various initiatives to support this. "Invest in Oxfordshire" provides a comprehensive package of support to assist companies in establishing their new operation in the area as well as providing on-going support. "Digital Oxford" is an initiative created to raise the profile of the digital sector and highlight the digital skills and expertise within Oxfordshire. Continued support and collaboration with the UK as a whole, including hotspot areas, will help to sustain the attraction of start-ups and growth in the creative and digital sector.

3.9 CRYOGENICS

Overview

Oxfordshire is home to the world-leading cluster of expertise on cryogenics. Cryogenics is the production and behaviour of materials at very low temperatures. The blend of academic, research and industrial expertise makes Oxfordshire home to the most powerful concentration of cryogenic expertise in the world. Cryogenics is a critical enabling technology with sub-sectors such as cryocoolers, instrumentation and superconducting magnets. Cryogenic technologies underpins around 17% of the UK economy, including many of our high-growth sectors, particularly space, life sciences, energy and quantum computing. Oxfordshire is responsible for the majority of the UK cryogenic sector. The Oxfordshire cluster includes:

- **Rutherford Appleton Laboratory** at Harwell Science and Innovation Campus, a world-leader in cryogenics. The Rutherford Appleton Library was responsible for the development of: the most successful closed-cycle cryocoolers ever flown in space; the ground-breaking 'Rutherford Cable' for use in high field magnets; and an extensive fleet of test cryostats supported by skilled technicians and full control and data logging capabilities. The campus is home to other research organisations and businesses including Cryox, the Diamond Light Source, and ISIS Neutron Source.
- The cryogenics cluster is spread across the ecosystem and contains a number of leading **businesses.** These include: **Oxford Instruments**, which supplies and supports market-leading research tools that enable quantum technologies, nano-technology, advanced materials and nano-device development. **Oxford Cryosystems,** a market-leading manufacturer of specialist scientific instrumentation best known for the Cryostream Cooler, the market-leading low temperature system used in X-ray crystallography. **Quantum Cryogenics** – provides quality electronic solutions for the cryogenic and transport industry. **Siemens Magnet** - designs and manufactures superconducting magnets within the Magnetic Resonance (MR) business unit for use in magnetic imaging scanners (e.g. MRI). Other companies include Innovative Cryogenic Engineering in

[37] Startups, retrieved from https://startups.co.uk/vc-funding-uk-start-ups-2017/

Witney and Thames Cryogenics in Didcot, a world-leader in the manufacture and supply of cryogenic piping.

- The **University Technical College in Didcot** is the first school globally to install a cryogenics lab.
- Oxfordshire has hosted the **largest conference on cryogenics in Europe** to date. It was attended by 492 delegates from across the world.

Links across the UK

- As a critical enabling technology, Oxfordshire's innovation in cryogenics will underpin economic growth in a number of high technology industry clusters across the UK – there is nowhere else in the UK with Oxfordshire's level of capability in this technology.
- Cryogenic technologies developed in Oxfordshire are also manufactured across the UK in areas such as the North East of England, creating high value jobs.

Global Competitors

- Cryogenics is an important and strategic technology that underpins developments across a number of high growth sectors. As a result, countries across the world, such as the USA, Japan and France are investing significant amounts into the development of this technology.
- Hudson Valley in New York, USA is a key competitor area where General Electric and IBM have research centres and are advanced in the subsector of superconducting magnets – this is an area where China is also strong and growing. In addition, California is home to the Cryonics Society of America, a member-run not for profit organisation that supports and promotes research and education into cryonics and cryobiology.

Conclusion

Sectors associated with cryogenics represent 17% of the UK economy, and the total (direct and indirect) GVA contribution of cryogenics-related activities to the UK economy is £324 million per year.[38] Cryogenic-related economic activities could contribute between £1.6 billion and £3.3 billion to the UK economy in the next 10 years**,** with STFC, its university partners and industry all being key players in delivering this growth.[39] Oxfordshire's world-leading cryogenics cluster needs to be better recognised, with more investment and research in order to capitalise on these market opportunities. New applications for cryogenics are also emerging, and Oxfordshire needs to be ready to establish leadership in these competitive landscapes.

[38] Science and Technology Facilities Council, retrieved from: https://stfc.ukri.org/research/engineering-and-enabling-technologies/the-uk-impact-of-cryogenics/
[39] Ibid.

Figure 3-8 RAL Space, Harwell Science and Innovation Campus

3.10 ENERGY

Oxfordshire is at the forefront of innovation in energy technologies and systems of the future. Oxfordshire is unique in the UK in its specialism in working to develop future energy systems and services and strengths in batteries and battery management – innovation and developments in battery storage will have significant benefits for other industries in which Oxfordshire is world-leading, such as connected and autonomous vehicles and space. Oxfordshire is also a national hub of fusion energy research, one of the most promising options for generating large amounts of carbon-free energy in the future. Oxfordshire's strengths include:

- Strengths in **future energy systems and services**. Capabilities in this area range from research in novel batteries and battery management systems, as well as in data analytics and in social science expertise. Research in this area is critical as industries converge – for example as transport becomes electric.
- Oxfordshire is home to the **Culham Centre for Fusion Energy (CCFE),** based at Culham Science Centre and operated by the UK Atomic Energy Authority (UKAEA). It is the UK's national laboratory for fusion research. Culham has made many major contributions to international fusion research and development. Today the UK fusion programme is centred on the innovative MAST (Mega Amp Spherical Tokamak) experiment and employs around 150 people. It participates in a coordinated European programme, which is managed by the EUROfusion consortium of research institutes which aims to achieve fusion electricity by 2050.
- CCFE hosts the world's largest magnetic fusion experiment, **JET (Joint European Torus),** on behalf of its European partners. This employs around 500 people, with around 350 European scientists visiting each year to conduct research and many from outside Europe.
- Oxfordshire is home to **The Faraday Institution,** the UK's independent institute for electrochemical energy storage science and technology, supporting research, training,

and analysis. Oxfordshire **businesses** such as **Tokamak Energy** are leading the way in developing scalable fusion energy solutions, and the **University of Oxford** and other research organisations provide a rich base of innovation on which the cluster depends.

- Oxfordshire also innovates with **low carbon** technologies. Low Carbon Oxford, a group of the major energy users in the city, public, private and academic, are working together to achieve the city's ambitious target to reduce emissions in Oxford by 40% by 2020.

Links across the UK

- UKAEA is a lead participant in the co-ordinated EU fusion programme managed by EUROfusion and operates the largest fusion device in the world, JET. By hosting JET, UKAEA has developed globally unique fusion capability, which is creating high value jobs and exports across the country. For example, the robotics capability at Culham has enabled major contracts worth >£200M to be won around the UK in the last few years, including supporting hundreds of jobs in the North West and North East.**Markets and global competitors**
- The UK is a strong player in energy and particularly benefits from strong collaboration with European in regards to fusion energy. Oxfordshire's strong links with the EUROfusion consortium serves to boost the industry in Oxfordshire, providing a strong European-wide cluster that can compete internationally. The consortium also collaborates outside of Europe, with partners including China, India, Japan, South Korea, Russia and the USA for the work at the International Thermonuclear Experimental Reactor (ITER).
- Oxfordshire's distinctive strength in energy systems is world-leading, but will be facing increasing competition from countries such as Japan and Canada.

Conclusion

Oxfordshire is at the forefront of innovation in a number of energy sub-sectors – the ones highlighted here are only specific examples and are not exhaustive. Oxfordshire's strengths as a national leader in fusion energy, and its distinctive strengths in researching future energy systems, will be important as the region and the country moves towards low carbon. This is a growing market that Oxfordshire is well placed to succeed in.

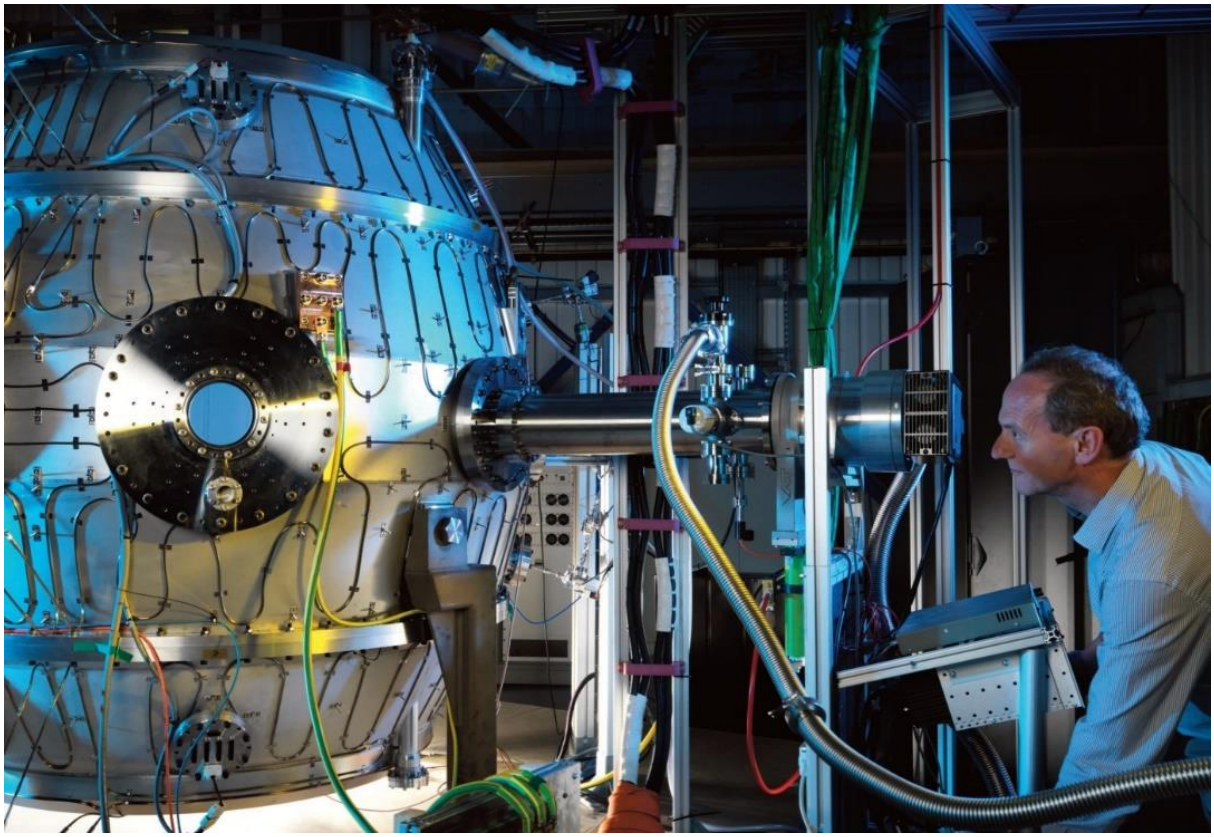


Figure 3-9 Tokamak Energy, Milton Park

4. THE FUTURE OF OXFORDSHIRE'S ECONOMY

4.1 INTRODUCTION

The previous chapters set out our vision for Oxfordshire to become a top three global innovation ecosystem, as well as the key industries in which Oxfordshire is globally competitive. These are the industries which Oxfordshire should focus on going forwards in order to push the UK to the forefront of innovation. This chapter now looks in more detail at Oxfordshire's future economy. It is split into three main sections:

- **[4.2] Key trends that are shaping Oxfordshire's future**. We know that our world is changing rapidly, with new global trends and technologies disrupting our futures. These are creating new challenges for society to respond to as well as opportunities for growth. This section introduces these trends and sets the scene for the work we have undertaken to understand more granular shifts that will affect Oxfordshire and its citizens from now until 2040.
- **[4.3] The 'do nothing' scenario**. In this section, we describe the 'do nothing' scenario for Oxfordshire, outlining likely outcomes in a future where the economy continues on its baseline trajectory without the implementation of the Oxfordshire Industrial Strategy or other initiatives to manage the growth trajectory.
- **[4.4] The 'go for growth' scenario**: This section sets out the results of Computable General Equilibrium (CGE) modelling to assess the impact of future policy interventions in Oxfordshire's economy from now until 2040 to identify what Oxfordshire's economy might look like in the future. This highlights the potential for Oxfordshire to double its GVA by 2040 to be worth £46 billion.
- **[4.5] Oxfordshire's business lifecycle.** Based on the Baseline Economic Review, this section sets out Oxfordshire's business lifecycle in three stages. Enabling businesses to move more rapidly through the lifecycle will be key to unlocking Oxfordshire's growth potential.

4.2 KEY TRENDS FOR OXFORDSHIRE

1. Oxfordshire can lead in an increasingly technology-reliant world

Technological breakthroughs in disciplines, such as AI and software robotics (SR) hold the promise of faster productivity growth and creation of entirely new markets. The Baseline Economic Review, building on work already completed in the Science and Innovation Audit, highlighted the strength of Oxfordshire's presence across the four underpinning technologies relative to Great Britain, concluding that the region is well equipped to lead in these technological shifts.[40]

2. Rapid urbanisation means Oxfordshire will need a renewed focus on competitiveness

Currently, more than half of the world's population live in urban areas, and this number is set to increase by around 1.5 million people every week.[41] A shift in preferences towards urban living

[40] Digital health, Space-led data applications, Quantum computing and Autonomous vehicles
[41] PwC analysis - United Nations population division

offers cities and regions across the world the opportunity to be substantial economic development tools, promoting inclusive growth. Cities and regions are now competing with one another for the best talent, investment and businesses. Moreover, Oxfordshire needs to understand that an important component of strengthening competitiveness is creating a region where people really want to work and live. The region is in a unique position to offer both urban and rural living. Other 'pull factors' include job prospects, good housing affordability and public transport as well as high quality civic space.

3. Emerging markets bring new opportunities for Oxfordshire

Large and fast-growth emerging markets like Malaysia, Indonesia and Brazil are going through significant transitions. Combined GDP for G7 countries is forecast to double between 2015 and 2050, from $34 trillion to $69 trillion.[42] Over the same period, combined GDP for E7 countries is expected to increase sevenfold, to $138 trillion in 2050.[43] This gives some sense of the 'size of the prize' for Oxfordshire's high potential businesses and cornerstone businesses; it points firmly to Oxfordshire's business community needing a robust approach to entering new markets and pursuing export growth.

4. An ageing population is placing greater emphasis on productivity to drive growth

It is positive news that we are living longer, but an ageing population is already putting pressure on health, social care and pension systems, and ONS projections suggest that this will intensify in the forecast period. A shrinking working-age population, coupled with more pensioners, means productivity will become more important (and challenging for Oxfordshire) as a driver of growth. This links closely with the stochastic frontier analysis in the Baseline Economic Review, which explored the factors behind firm-level efficiency in Oxfordshire. The analysis concluded that there is large variation in productivity levels within Oxfordshire that will need to be addressed.

5. Oxfordshire must embrace greater economic connectivity

The world is the most connected it has ever been. There are now seamless flows of capital, people and information across regions, nations and continents. This evidences how important connectivity is from a demand side but, as highlighted in the baseline report, physical clustering (i.e. agglomeration) is also integral from a supply side perspective. A focus on embracing greater competition and recognising agglomeration opportunities will help the region achieve its vision in becoming a top three global innovation ecosystem by 2040. In particular, the opportunity for Oxfordshire to help shape the Oxford-Cambridge Arc will play an important role in opening up new opportunities for agglomeration.

6. Oxfordshire has the capabilities to harness growth from these global shifts

It is crucial that Oxfordshire recognises that these global forces are transforming its businesses, the marketplace and society. Oxfordshire is in a prime position to benefit from these shifts, owing to the favourable high-tech sectoral mix in its economy and the strong skills and knowledge base within its labour force. Adapting to these trends will ensure the region is fit for sustainable growth. The final local industrial strategy will provide the platform for Oxfordshire to show how it intends to navigate these shifts by leveraging its unique capabilities.

This is a critical moment for Oxfordshire

Oxfordshire has reached a critical moment in its economic development. Oxfordshire must consider whether it will continue with robust but unspectacular growth, or pursue a 'go-for-growth'

[42] US, Japan, Germany, UK, France, Italy, Canada
[43] China, India, Brazil, Russia, Indonesia, Mexico, Turkey

scenario that implements the full range of interventions in the document. This is a vital decision, as it will fundamentally impact the economic strength of the region, the standard of living of its residents and lastly the future brand of the region. If pursued, this scenario will seek to supercharge Oxfordshire's innovation ecosystem and take it to the world.

4.3 HOW WOULD OXFORDSHIRE FARE IN A 'DO NOTHING' SCENARIO?

In this section, we describe the 'do nothing' scenario for Oxfordshire, outlining likely outcomes in a future where the economy continues on its baseline trajectory without the implementation of the Oxfordshire Industrial Strategy or other initiatives to manage the growth trajectory.

More specifically, we have identified three themes, drawn from the findings of the Economic Baseline Review and the likely trends that we can expect in these areas by 2040. These directly feed into the counterfactual scenario, as they will have a sizeable influence on the region's future growth trajectory. The three key themes identified are:

1. Oxfordshire has a strong and dynamic workforce
2. Oxfordshire's population is ageing, which will place strain on its future workforce
3. Oxfordshire's cost of living could be restricting growth

The baseline scenario provided below will be the counterfactual for the computable general equilibrium (CGE) modelling to assess the impact of future policy interventions on Oxfordshire's economy. This means that results from the economic modelling of the go-for-growth scenario will be relative to this baseline trajectory.

Below we explore these three themes in more detail, including the potential impact they could have on Oxfordshire.

1. Oxfordshire has a strong and dynamic workforce

The Oxfordshire economy is based around strong skills and knowledge base. The Economic Baseline Review highlights that over 67% of its working-age population is educated to NVQ3+ and above, equivalent to A-levels and BTEC qualifications. This puts the region in a good place to adapt to changes in the labour market and quicken the rate of economic growth.

A successful economy requires a broad mixture of individuals. The workforce needs to comprise those who completed higher education, those with vocational training and those with entrepreneurial traits. This is particularly applicable to Oxfordshire's emerging technologies. In a sector such as autonomous vehicles, all three types of talent are essential to designing the systems, manufacturing the final product and bringing the new technology to market.

Businesses are attracted by the potential efficiency savings that automation and related technologies bring. However, governments are concerned about the displacement of jobs in the labour market. The main concern centres around how these disruptive technologies will impact jobs and the role of workers. Consensus has formed around the idea that a job is at higher risk of automation if it largely consists of manual and routine tasks. In March 2017, PwC analysis found that up to 30% of UK jobs were susceptible to automation from robotics and AI by 2030.[44] To put this into perspective, a 15% fall in the number of jobs in Oxfordshire would be equivalent to the economy losing the entirety of its education sector. However, it is promising to

[44] PwC, retrieved from: www.pwc.co.uk/press-room/press-releases/Up-to-30-percent-of-existing-UK-jobs-could-be-impacted-by-automation-by-early-2030s-but-this-should-be-offset-by-job-gains-elsewhere-in-economy.html

see that the region's three largest sectors, education, professional services and health are considered lower risk, according this analysis. Other, more vulnerable industries include transportation & storage (where 56% of positions are at high risk of automation), manufacturing (46%) and retail (44%). These three sectors together account for around 20% of total jobs in Oxfordshire.[45]

The research also suggests that private-sector employees and particularly those in SMEs are most at risk (34% of jobs at high risk), compared with the public sector (22%). This is explained by the differing higher education requirements for jobs in the public sector versus the private sector. This emphasises the point that Oxfordshire will need to engage and support its local businesses in creating higher skilled and thus higher value added jobs which will be less at risk to automation. Building on the four underpinning technology sectors in the region, higher value jobs are already being created in the energy, motorsport and cryogenics sectors.

The study concluded that the displacement of jobs would be largely offset from the creation of new jobs elsewhere in the economy. This secondary impact is much more difficult to quantify. However, automation and related technologies bring the huge potential to boost productivity and increase wealth in the longer term for all citizens.

Sector	Employment share of total jobs (%)	Job automation (% at potential high risk)
Agriculture, forestry & fishing	0.1%	18.7%
Mining, quarrying & utilities	0.8%	23.1%
Manufacturing	7.0%	46.4%
Construction	5.4%	23.7%
Motor trades	1.9%	44.0%
Wholesale	4.0%	44.0%
Retail	8.6%	44.0%
Transport & storage	3.8%	56.4%
Accommodation & food services	6.5%	25.5%
Information & communication	5.6%	27.3%
Financial & insurance	1.2%	32.2%
Property	1.9%	28.2%
Professional, scientific & technical	11.8%	25.6%
Business administration & support services	7.8%	37.4%
Public administration & defence	2.7%	32.1%

[45] Please note that this is an indicative analysis from a UK wide study, meaning the percentages provided are not open to some slight variation given the Oxfordshire context.

Sector	Employment share of total jobs (%)	Job automation (% at potential high risk)
Education	15.6%	8.5%
Health	11.3%	17.0%
Arts, entertainment, recreation & other	4.0%	22.3%
Total for all sectors	100.0%	30.0%

Source: ONS, OECD and PwC analysis

Figure 4-1 Employment shares and the estimated proportion of jobs at potential high risk of automation by early 2030s for all Oxfordshire industry sectors.

2. Oxfordshire's population is ageing, which will place strain on its future workforce

According to ONS projections, Oxfordshire will have an additional 60,000 people aged 65+ living in the region by 2036.[46] Over the same period, the working-age population is forecast to contract by around 10,000 people. A sustained increase in the dependency ratio for Oxfordshire, rising from 0.55 to 0.68 by 2036, will place greater pressure on workers to increase their productivity to keep up with the output generated today. This trend could threaten Oxfordshire's net contribution to the exchequer, were tax revenue to fail to grow sufficiently to balance the additional government spending required to support an older population.

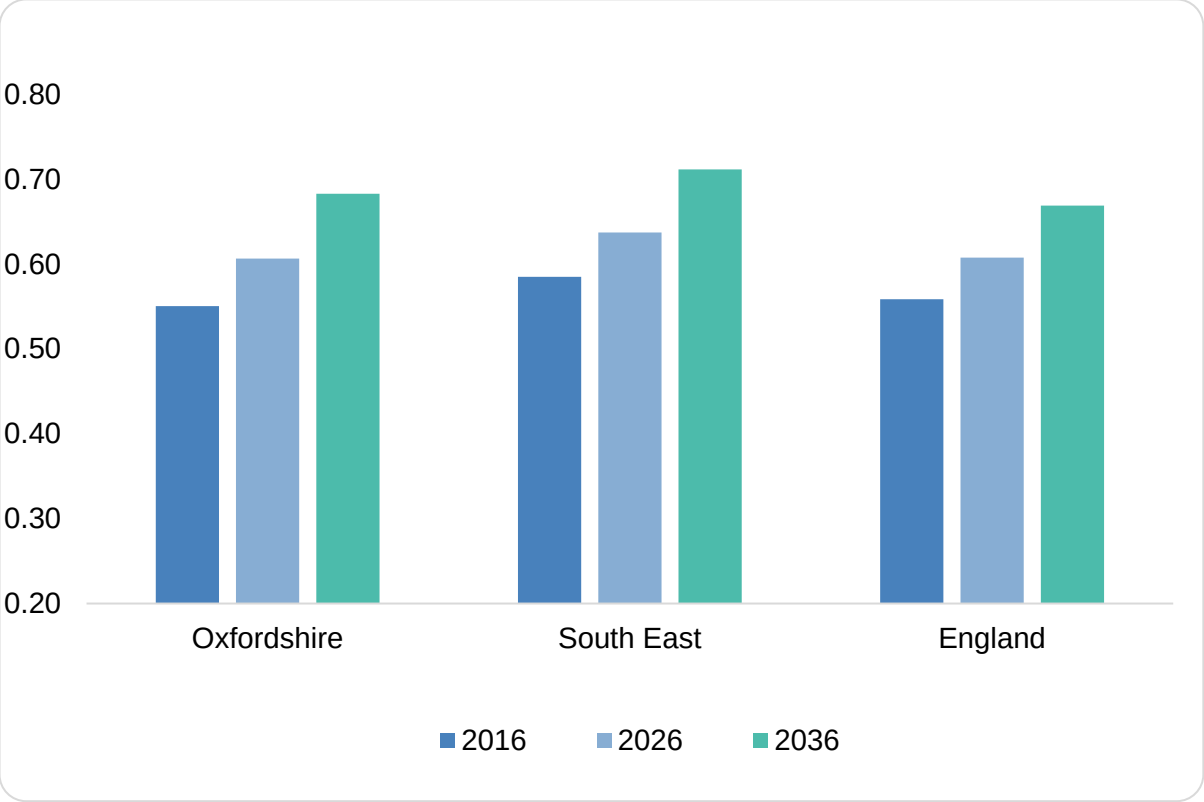


Figure 4-2 Oxfordshire old-age dependency ratio, 2016-36

[46]https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/methodologies/nationalandlocalauthoritylevelpopulationestimates

To offset some of these higher costs, Oxfordshire should think about how it can encourage and support older workers to remain in the workforce. This would boost regional output and bolster tax revenue. It could also help to improve the health and wellbeing of older people by keeping them mentally and physically active. This issue could be approached in a number of ways, and we acknowledge some solutions may require further policy changes from Central Government.

It is evident that Oxfordshire's demographics pose a challenge to the region's stated ambitions. The region will need to think creatively about how it can support workers throughout their careers, so that they can contribute to society for longer. A working-age pool with both skills and longevity will help the region reach its fastest possible rate of GVA growth.

- **Increasing the retirement age:** Under current UK law, the State Pension age is due to increase to 68 between 2044 and 2046. Increasing the retirement age can bring about a number of benefits such as sustaining tax revenues; increase the value of the state pension and gives individuals working in fixed retirement age professions greater flexibility to work longer.
- **Introduce financial incentives to encourage later retirement:** Germany's 'Perspective 50 Plus' programme uses a range tools, such as wage subsidies for enterprises and placement activities, in order to encourage those over 50 to stay in the workforce for longer. [47]
- **Place greater emphasis on lifetime learning and retraining:** Older employees working in roles at lower risk of automation will be critical to maximising gains from technology. It will be crucial to invest in training older generations as technology continually changes, ensuring that as people age they are thriving in the new environment. This directly aligns with the region's greater focus on technology-enabled sectors to drive growth in the coming years.
- **Become more flexible:** Oxfordshire businesses should be encouraged to offer partial retirement options, redesign offices and roles to meet the changing needs and preferences of older workers.

3. Oxfordshire's cost of living could be restricting growth

House prices in the South East are expected to grow just over 3% on average in the period between 2018 and 2022, unlike London, where house price growth projections over this period are stagnant. London (£478,853), followed by the South East (£322,096), have the highest median house prices across the UK.[48]

Despite house price growth in the South-East expected to be below the UK average, the region is likely to catch up to London's high living costs relatively quickly. This contrasts to the West Midlands, which has higher projected growth rates but from a much smaller house price level.

[47] OECD, retrieved from http://www.oecd.org/employment/leed/37729545.pdf
[48] Numbeo, retrieved from https://www.numbeo.com/cost-of-living/

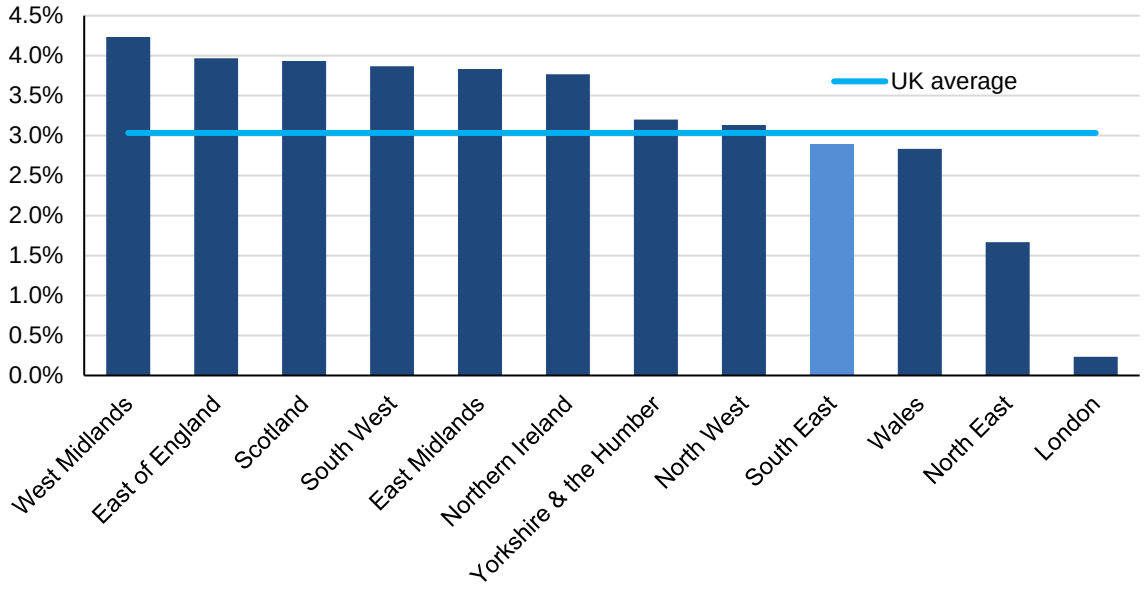


Figure 4-3 Average house price growth, 2018-22, by UK region.

House prices are a significant contributor to the cost of living challenge and an indicator of affordability within an area. On a more granular level, the Baseline Economic Review looked at the median house price to earnings ratio, where Oxfordshire stood out to score poorly on measures of housing affordability relative to local wages. Given this and the fact that house prices in the South-East are projected to grow in line with the rest of the UK, it is likely that the challenge will worsen. This could be managed by rising productivity levels being matched with an increase in wages or directly addressing the housing shortages. Currently, statistics suggest that Oxford ranks 4th out of UK cities in terms of the Cost of Living, with the largest proportion (37.1%) of income being spent on rent.[49] Although London ranks first, the projections for higher house prices in the region within which Oxford lies is likely to close this gap.

The lack of affordability has implications for the labour market and hampers growth for the economy as a whole. Sustaining a healthy market will come about from either attracting new talent or retaining existing talent within the region. The BEIS report, which maps local comparative advantages in innovation by LEP, highlighted the fact that over 1/3 of University of Oxford graduates left Oxfordshire in 2012/2013 rather than remaining in the district, which could worsen with growing house prices.[50] Graduates with desirable skills, discussed earlier in this chapter, could be deterred from living and working in the region. This limits the availability of skills for the innovative and high-tech sectors, which show great promise to accelerate regional growth.

[49] ONS
[50] BEIS, retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/546999/bis-15-344-mapping-local-comparative-advantages-in-innovation-framework-and-indicators.pdf

4.4 THE GO-FOR-GROWTH SCENARIO: DOUBLE THE OXFORDSHIRE ECONOMY IN REAL GVA TERMS BY 2040

We will be using Computable General Equilibrium (CGE) modelling to assess the impact of future policy interventions on Oxfordshire's economy over the forecast period until 2040. The modelling assumptions will incorporate the planned interventions outlined in the final Oxfordshire Industrial Strategy document which are expected to bring about a step-change in economic growth. The results will be presented relative to the 'do nothing' scenario, which has been described earlier in this document.

More specifically, CGE models are highly regarded in policy research and are used extensively by central government to appraise policy options. All of this ensures that a robust economic evidence base will underpin the Oxfordshire Industrial Strategy.

Changes in policies impact on key economic parameters which are introduced as 'shocks' to the model. These often have significant general equilibrium effects. This is because economic agents adjust to these changes by reallocating consumption and production decisions until equilibrium is restored again. Using our dynamic model, we can assess the sectoral and economy-wide impacts of a policy change on an annual basis over time. The model can also be run with different sets of parameters with relative ease. For example, it can be run with different assumptions on policies to boost labour productivity, and compare the impact of certain policy interventions.

What is a CGE model?

A CGE model combines economic data and a complex system of equations to capture the interactions between economic agents – households, firms and the government - through different channels, such as labour markets, capital flows, consumption, product demand, taxes or fiscal transfers. We build dynamic CGE models: households and businesses to take into account both current and future expectations, making decisions over time accordingly.

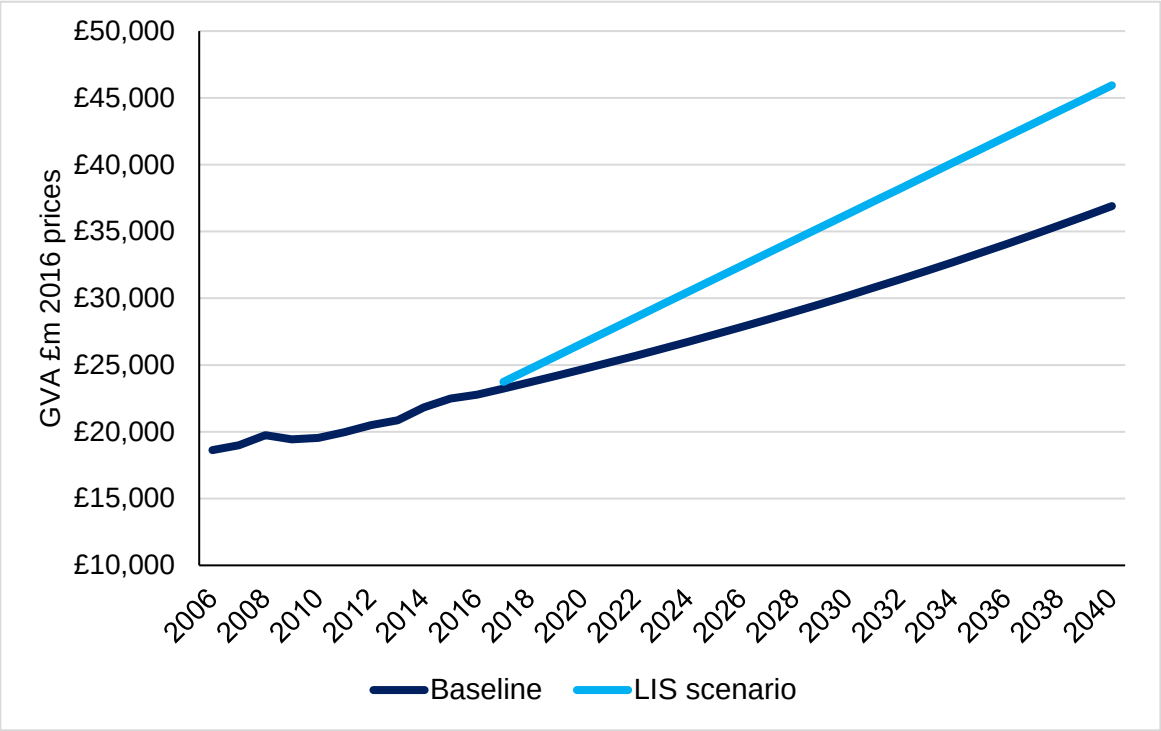
On a technical basis CGE models are sometimes criticised for being too simplistic in terms of modelling adjustment processes in the economy. The "E" in the title refers to equilibrium – meaning it is assumed that markets clear. In practical terms this means that 'supply = demand' and in the Oxfordshire housing market we know that this is not true. In fact it is not true in any of the key markets in Oxfordshire – the labour market is tight and nearly at fully employment and while the region is successful in attracting international capital. Lastly, the spatial element of the CGE model refers to its regional components. The current version of the model captures the whole of the UK economy and can be disaggregated down to the county and local authority level.

If Oxfordshire pursues a go-for-growth scenario, we could double Oxfordshire's GVA in real terms by 2040 to be worth £46bn.

In a scenario where the Oxfordshire Industrial Strategy is implemented, Oxfordshire's economy will grow on average at 2.9% annually in real terms until 2040, which is 0.9% higher than in the baseline trajectory. This is equivalent to Oxfordshire's economy doubling in size (+£23 billion). These figures help reflect the significant economic prize which is available to the region if there is buy-in from all stakeholders. To put this opportunity into perspective, an additional £9 billion in 2040 above baseline levels, is comparable to the current size of the public admin, education and health sectors in Oxfordshire multiplied by two.

This growth will be innovation-led, driven by a 2% increase in productivity per annum as well as 108,000 new jobs.

The economic modelling places innovation-led productivity as the main driver for Oxfordshire's economic growth over the period until 2040. This reflects Central Government's views that the key purpose of the Oxfordshire Industrial Strategy is to promote a step change in productivity growth based on Oxfordshire's distinctive sectoral strengths, which have been highlighted in the previous baseline report. Average productivity levels are forecast to rise from £53,462 in 2016 to £85,991 in 2040. This means that productivity will maintain robust growth of 2% annually until 2040. [10]



Source: ONS and PwC analysis

Figure 4-4 Oxfordshire real GVA, 2006 – 2040, Baseline vs LIS scenario.

The number of jobs created across Oxfordshire in this high growth scenario is estimated to be 108,000, between 2018 and 2040 (starting in 2019). Job creation will be balanced across both cornerstone and breakthrough business sectors. This will ensure Oxfordshire's economic growth is inclusive and enjoyed by all residents, promoting jobs that are both productive and well paid.

The CGE modelling approach does not easily allow for an apportionment of jobs by each individual driver of job growth. The main drivers of job growth will be:

- **Displacement**: There will be some displacement of businesses and jobs, both from surrounding regions into Oxfordshire and vice versa. However, the net impact of this would be relatively small.
- **Greater attraction and retention of labour**: This driver is underpinned by: (i) greater graduate retention due to increased job prospects in the region; (ii) increased productivity will subsequently mean higher wages and attract new people into the employment pol, who were for example previously economically inactive, (iii) we have also assumed that people will stay in the workforce for longer, because of the rise in retirement age as well as greater alignment of jobs to an older workforce, due to the increasing move towards fewer manual jobs in the future.

- **Labour to capital ratio.** As the Oxfordshire economy expands, we have assumed that the relative value of labour to capital in the economy increases. This is because labour will become more productive due to the adoption of new technologies and processes.

Oxfordshire's step change in economic performance will deliver growth for the UK more widely

This boost in Oxfordshire's GVA will contribute to the UK government's inclusive growth agenda in two ways:

1. **For every £1 invested in Oxfordshire, £4 is generated across the rest of the UK economy.**

During a period of economic expansion in a region, such as Oxfordshire, economic activity will spill-over into surrounding economies, stimulating additional demand for goods and services elsewhere. This demand will support other UK businesses and help sustain and create jobs through direct, indirect and induced impacts. For example, new technologies and ideas developed in Oxfordshire's digital health sector may be manufactured and distributed from elsewhere in the Oxford-Cambridge Arc. These linkages demonstrate how integral Oxfordshire's growth can be for the performance of the UK as a whole. Examples of these links for each industry were set out in the previous section.

What are knowledge spill-overs? This is best explained when new knowledge acquired through product and service development in Oxfordshire, provides economic, social and environmental benefits to those located outside of the region. The greater the knowledge created and transferred, the greater the scale of spill overs anticipated. This can take the form of both formal and informal knowledge sharing such as through the use of published research.

2. **An increase in tax revenue for Central Government due to increased job creation**

Government tax revenues come from personal income taxes, indirect taxes less subsidies, corporate income taxes and is measured as the total amount of tax revenues generated for each level of government. This reinforces the return on investment from funding programmes and projects across Oxfordshire, given these substantial returns to the public purse.

Future interventions must pull on the right levers to unlock Oxfordshire's economic success

Oxfordshire can only achieve this prosperous economic outlook if there are clear objectives for all stakeholders to strive towards. The five levers, set out below, provide the necessary direction for stakeholders to focus on, in order to promote a step-change in the region's economic growth trajectory. Furthermore, the agreed interventions outlined in the Oxfordshire Industrial Strategy should directly align with these objectives, ensuring efforts and resources of all stakeholders are efficiently utilised to benefit the economy.

- **Enable productivity growth to increase to 2.0% annually**, underpinning higher economic output levels. Improving productivity is a core aspiration of the Oxfordshire Industrial Strategy, and so is a central component of future plans for growth.
- **Create distinctive and connected neighbourhoods** that will provide affordable, attractive homes within vibrant communities. The integration of technology to create smart, efficient and connected communities will help to attract the future workforce Oxfordshire needs to thrive and deliver the growth projected.

- **Increase business investment in both business groups in Oxfordshire**. Oxfordshire should help cornerstone businesses with earlier adoption of new technologies, improving firm efficiency. In addition, sufficient financial support and entrepreneurial guidance will be required for breakthrough firms to scale effectively.
- **Deliver higher value adding jobs which will pay higher wages for residents**. Lower value adding jobs, due to their characteristics, are more vulnerable to automation in the future. Therefore, Oxfordshire should support the creation of high skilled jobs which will provide sustainable employment throughout the twenty first century.
- **Capture more opportunities through the business lifecycle**. Oxfordshire is world-class across research and development activities. However, it also has the capabilities to retain more business within the region after this initial stage of the lifecycle. A greater focus on scaling, commercialising and distribution activities will help deliver a wide variety of jobs for local residents across industries and ensure the region is working at full capacity.

4.5 OXFORDSHIRE'S BUSINESS LIFECYCLE

To achieve and manage this growth, we will ensure that businesses in Oxfordshire have the support and the space they need to grow

This is a significant step-change in growth for Oxfordshire. To enable this growth and to ensure that it is managed, we have set out how we will support Oxfordshire's businesses at each stage of the business lifecycle, and how Oxfordshire as place will develop to facilitate this.

Oxfordshire's business life cycle, outlined below, contains three key stages of maturity. It has been produced as a result of the baseline economic analysis to highlight the key stages at which Oxfordshire is successful and in which Oxfordshire has the potential to generate further growth. Whilst Oxfordshire excels in idea generation (Stage 1), we can do more to facilitate rapid growth through testing and product development (Stage 2). This will then deliver economic benefits more widely to the Oxford – Cambridge Arc and the UK economy through commercialisation (Stage 3). The following pages outline how Oxfordshire will develop as a place to enable this.

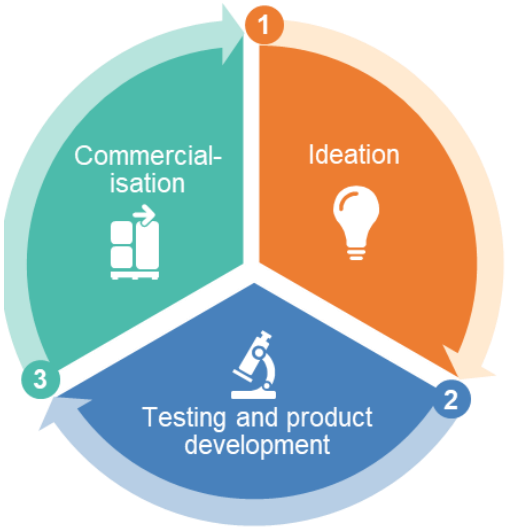


Figure 4-5 The Oxfordshire business lifecycle

Stage 1: Ideation. This is the idea generation stage of business development, harnessing Oxfordshire's world-class research and development capabilities. Oxfordshire has unique strengths in this stage, home to world-class universities, innovation assets and research and development capabilities. Our strength in this stage is clear – for example the Oxfordshire LEP area is ranked third in the UK for percentage of firms investing in R&D; we have the largest investment fund for university spin-outs globally; and Oxford University has the highest intensity of spin out companies in the country.[51] Ideation in Oxfordshire is what generates the increasing number of

[51] Enterprise research, retrieved from https://www.enterpriseresearch.ac.uk/wp-content/uploads/2017/06/Benchmarking-Innovation.pdf; Transformative Technologies Alliance,

breakthrough businesses identified in the baseline economic review.

Stage 2: Testing and product development. This phase includes the testing and prototyping of new business ideas, in preparation for bringing them to market. Many businesses that started in Oxfordshire have expanded and grown to scale successfully by testing and developing products that can in the future be brought to market. Oxfordshire does well in this stage with a large number of science, technology and business parks and clusters around key sectors and technologies. Providing an environment for businesses to test, evaluate and develop products is a way in which businesses in Oxfordshire can be better supported to do this.

Stage 3: Commercialisation. This is the stage where Oxfordshire has the greatest potential to capture good growth for the region and generate additional growth for the rest of the UK. For businesses to commercialise their innovation and technology, they need access to business space which means unlocking land and resource. The business environment of the ecosystem must also be mature, allowing for the right talent, finance and infrastructural enablers to be in place. By doing this we can enable Oxfordshire to retain aspects of the downstream operational chains of breakthrough businesses.

4.6 MEASURING OXFORDSHIRE'S PERFORMANCE

Oxfordshire should measure its performance, ensuring it is on track to achieve its vision by 2040.

It is not enough for Oxfordshire to simply set out a clear plan of interventions or ambitions in the Oxfordshire Industrial Strategy. The region will also have to measure whether these actions are making a tangible difference on the outcomes that matter to local communities, businesses and our national economy. This will help us to understand the progress we are making against our stated vision and objectives.

A performance framework has been developed, consisting of indicators across the six essential characteristics of a global innovation ecosystem. These indicators will be used to inform the region, identifying strengths as well as areas for improvement in its performance. The framework outlines the performance indicator, the data source to be used and lastly the relevance of this indicator in helping the region achieve its vision.

Characteristics	Performance Indicator	Data Source	Relevance
Iconic Brand and Vision	Tourism numbers and spending	Visit Britain Survey and Database	Tracking tourism numbers and tourism spend helps to depict how attractive Oxfordshire is as a destination to both domestic and external visitors. As the Oxfordshire brand gains more traction globally, we would expect an increase in the numbers of tourists visiting the region.

'Science and Innovation Audit', 2017; Oxford University Economic Impact Assessment, Biggar Economics, April 2017

Characteristics	Performance Indicator	Data Source	Relevance
	International coverage	Coverage of Oxfordshire's innovative ecosystem by major economic publications (WSJ, The Economist)	The coverage from such publications will allow Oxfordshire to ascertain the success and brand of the region's innovative ecosystem.
Liveable place	Cost of living	House price Index, Land registry Affordability measures (e.g. House price to earnings ratio, types of housing developments)	The greater the number of affordable houses being built will attract younger and dynamic demographics, ensuring a healthy supply of workers for both breakthrough and cornerstone businesses.
	Inequality/ Deprivation	English Index of Multiple Deprivation (IMD)	Outlining how well the gaps between rich and poor areas in Oxfordshire are being addressed will be key to the progress of the region as a whole. There is an opportunity for inclusive growth across Oxfordshire, delivering benefits across localities and the demographics spectrum.
	Secondary School attendance and attainment records	DFE school performance table	The continual improvement of secondary education ensures there is a high standard of foundational skills across the Oxfordshire workforce. Ensuring this strong education base will raise the overall opportunities to young people across the entirety of Oxfordshire.
	Inward FDI	This is currently only available at NUTS 1 level (e.g. 12 UK regions)	FDI measures the value of investment from abroad and indicates whether foreign investors feel Oxfordshire is a business friendly region. Increased levels in FDI will help promote job creation and fund local businesses throughout the scaling phase.

Characteristics	Performance Indicator	Data Source	Relevance
	Funds operating in Oxfordshire	OxLEP reviews on new capital aligned to the Oxfordshire Industrial Strategy	A large number of local funds means there is financial support available to local businesses. The expansion of established funds would enhance the overall growth potential of both cornerstone and breakthrough businesses across Oxfordshire.
	No. of start-ups and university spin-outs	Nomis - No. of enterprise births and deaths Internal records from both University of Oxford and Oxford Brookes on spinouts	The number of start-ups and spin-outs are a direct measure of successful entrepreneurial and commercial culture in an economy. Oxfordshire strives to give additional support to breakthrough businesses, who have the capability to drive productivity growth across the economy. Therefore a further and important benchmark is the growth of these firms into Gazelles or Unicorns, this growth trajectory is vital in Oxfordshire fulfilling its full potential.
	Uptake of Entrepreneurial Courses	Enterprising Oxford data and records	This can be directly attributed to successful implementation of a commercial culture and the further encouragement of enterprise in Oxfordshire.
	GVA growth rates	ONS GVA by NUTS3 region	GVA growth rates provide an indication of whether Oxfordshire's economy is expanding at a faster or slower pace, compared to the rest of the UK. It also indicates the contribution made by Oxfordshire to the UK economy as a whole.

Characteristics	Performance Indicator	Data Source	Relevance
	Cornerstone business adopting transforming technologies.	Local surveys conducted within Oxfordshire	Ensuring that Oxfordshire's cornerstone business are adapting and growing alongside transforming technologies is key to ensuring the backbone of Oxfordshire's economy remains strong and resilient.
	Oxfordshire's Science Parks	Uptake of Real Estate space and R&D	These assets must be continually prioritised and reviewed to ensure they are continually sustainable and are being maintained. To allow flows of R&D and innovation continue to come to Oxfordshire.
	Oxford University and Oxford Brookes	Times University Rankings Research funding, published by respective Universities	Oxfordshire's Universities are already globally renowned. This status needs to be maintained for two reasons: firstly, ensuring a skilled graduate workforce and secondly for tourism purposes, as people want to come and see these anchor assets in the region.
	Graduate retention rate	Higher Education Statistics Agency (HESA) – Destination of leavers in higher education	To maximise the contribution of Oxfordshire's world class universities, graduate retention must be prioritised and continually improved to ensure there is a large supply of skilled young people entering the local labour market.
	Apprenticeships	Skills funding agency (OxLEP currently gather this information)	Apprenticeships can be directly attributed to enhancing the supply of skilled workers and supporting the growth of SME's and MME's. Apprenticeships offer invaluable industry specific experience and incentivise younger people to enter the workforce at an earlier age, contributing to the local economy for longer.

Characteristics	Performance Indicator	Data Source	Relevance
	Employment rate	Office for National Statistics	To fully utilise the skilled workforce Oxfordshire is investing in and has already built, the employment rate needs to be at a maximum to ensure the region is operating at full capacity.

5. SPATIAL IMPLICATIONS

5.1 INTRODUCTION

Our vision is to become a top three global innovation ecosystem, doubling our GVA to £43 billion and creating 108,000 jobs. It is critical that we ensure this growth is sustainable and can grow to scale. This is why in this chapter we set out a spatial vision for how growth in Oxfordshire can be sustainable, enhancing the natural environment and quality of life for all of Oxfordshire's residents.

We have developed this vision by assessing growth needs and existing land and connectivity constraints and opportunities across the county. The first part of this analysis is in the Baseline Economic Review. This provided an assessment of the existing land constraints and opportunities, taking into consideration environmental constraints, such as Areas of Outstanding Natural Beauty (AONB) and Green Belt land. This was combined with opportunity growth factors, such as economic density and population density. The analysis has indicated those areas which are most suited to economic growth.

This section takes this further, mapping the innovation ecosystem in more detail and setting out a spatial vision. The vision originates from a business-orientated perspective of growth that focuses on graduating knowledge assets into successful enterprises by providing fit-for-purpose growth locations. It is formulated to minimise impact on the natural environment and retain the sense of place that makes Oxfordshire unique. We have spatially mapped economic clusters to match the business lifecycle in our strategy. This will ensure that different types of business are enabled to move more quickly through Oxfordshire's business lifecycle, to grow to scale and move into commercialisation.

This chapter is divided into the following sections:

- **[5.2] Spatial model and mapping.** This section sets out how we developed a spatial model that uses Geographical Information Systems (GIS) and local data sources to provide a high-level spatial analysis of urban industrial demand and land suitability.
- **[5.3] Spatial-economic supply-demand analysis.** This spatial analysis has been paired with the economic assessment of Oxfordshire. The analysis showed clear different spatial demands for businesses at different stages of the business maturity lifecycle (ideation, innovation and commercialisation). For example, businesses within the ideation phase require strong links with Universities whereas those approaching commercialisation require access.

Taking into account the above analysis, we developed a spatial vision concept for the Oxfordshire Industrial Strategy that was tested at a number of spatial development workshops with key stakeholders from public, private and academia sectors. Following further refinement, a final spatial option for the Oxfordshire Industrial Strategy was developed based on the analysis in the previous stages – we set out the vision in this section in three stages.

- **[5.4] The spatial vision: a network of centres.** Taking into account the above analysis, we developed a spatial vision concept for the LIS that was tested at a number of spatial development workshops with key stakeholders from public, private and academia sectors. Following further refinement, a final spatial option for the LIS was developed based on the analysis in the previous stages – we set out the vision in this section.
- **[5.5] The spatial vision: a living laboratory.** This section sets out the concept of Oxfordshire as a living laboratory – a testbed for innovation to solve the UK's Grand

Challenges and accelerate the adoption and accessibility of innovation across the ecosystem.

- **[5.6] The spatial vision: multi-level physical and digital connectivity.** This section provides a focus on the types of critical infrastructure that are required to deliver Oxfordshire's economic ambition. This includes consideration of physical infrastructure, digital infrastructure, energy infrastructure and major new developments.

5.2 MAPPING THE OXFORDSHIRE INNOVATION ECOSYSTEM

We developed a spatial model using Geographical Information Systems (GIS) and local data sources to provide spatial analysis of urban industrial demand and land suitability. For each MSOA (Middle Super Output Layer) within Oxfordshire (see below) an agglomeration of industrial demand drivers and physical constraints to urban development have been used to assess the current and future state for development of industrial activity. This is a high-level analysis which considers the key indicators which impact the development of industrial activity which will help to inform how best to plan for and manage future industrial growth, including the provision of urban infrastructure.

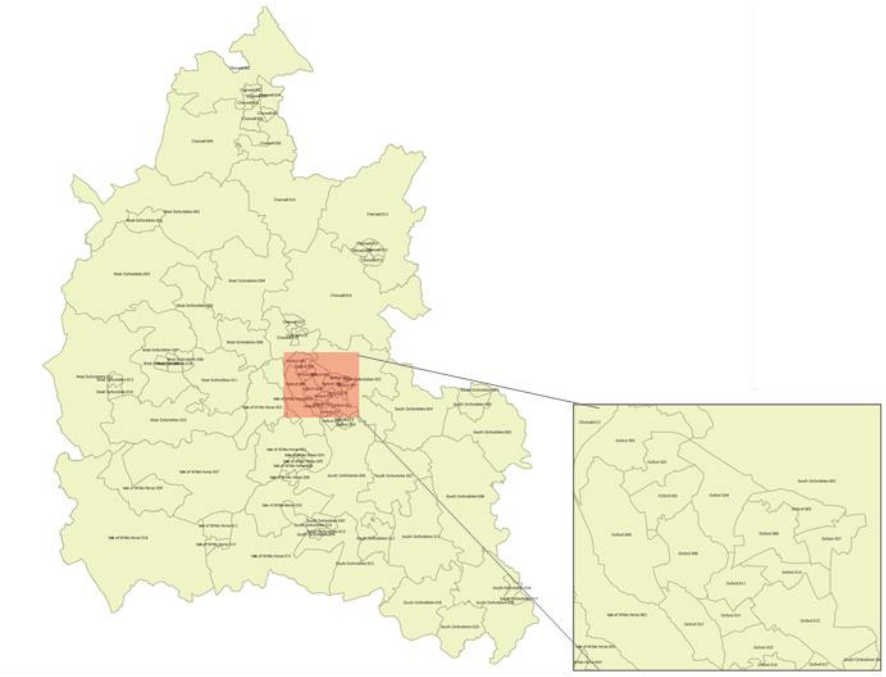


Figure 5-1 Spatial view of Oxfordshire by MSOA (Middle Super Output Layer) boundaries within Oxfordshire

Step 1

Fourteen indicators have been used taken from different GIS layers and publically available datasets (Appendix A). A score has been given for each indicator within every MSOA which are assigned on the basis of whether the indicator is an accelerator or decelerator of industrial demand. An accelerator is deemed to enhance and promote economic growth whereas a decelerator is a blocker to economic growth.

Step 2

Each MSOA has been ranked across each of the indicators with a high rank indicating a positive influence on the suitability for urban growth. The ranks have then be amalgamated and weighted to project future urban demand and suitability. The model draws a distinction between current

and future growth categorising: (1) the current state drivers and constraints for industrial growth; and (2) the future state drivers and constraints for industrial growth.

Step 3

The final output from the model are two distinct map showing the baseline and future state demand for industrial growth across the MSOAs within Oxford:

- The **baseline** provides an overview of the current sustainability for industrial growth across the MSOAs
- The **future state** provides an assessment of the future suitability for industrial growth across the MSOAs taking data from the CGE modelling.

The diagram below shows the different indicators which make up the spatial demand mapping. They are categorised by existing and future indicators, with an upward arrow representing a positive factor and a downward arrow representing a constraint to growth. The final output is a basemap showing which areas in Oxfordshire would be most suited to industrial growth. For the purpose of the Oxfordshire Industrial Strategy, this is not shown on the final output as it is intended to be a conceptual map.

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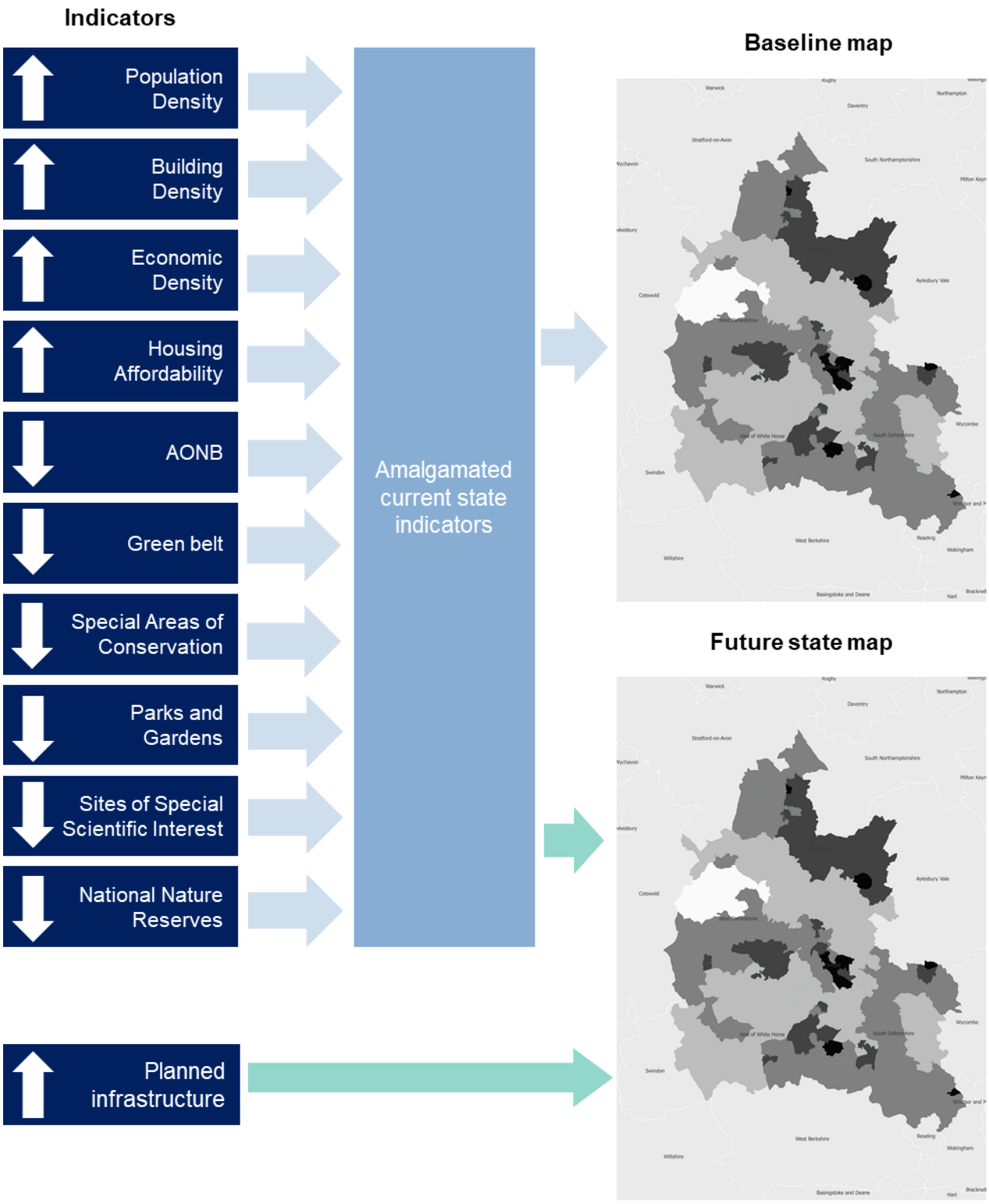


Figure 5-2 Illustration of spatial model and mapping inputs and outputs

Spatial-economic supply and demand analysis

The economic assessment of Oxfordshire showed clear different spatial demands for businesses at different stages of the business maturity lifecycle (ideation, testing and product development, and commercialisation). For example, businesses within the ideation phase require strong links with Universities whereas those approaching commercialisation require access.

The Oxfordshire innovation ecosystem has therefore been aligned to the business lifecycle with three distinct stages spatially mapped across Oxfordshire. The vision originates from a business-orientated perspective of growth that focuses on graduating knowledge assets into successful enterprises by providing fit-for-purpose growth locations.

We have spatially mapped economic clusters to match the business lifecycle in our strategy. This will ensure that different types of business are enabled to move more quickly through Oxfordshire's business lifecycle, to grow to scale and move into commercialisation.

This recognises the areas that are most suited for each stage of the business lifecycle. However, we recognise that such activities are not exclusive and will occur across the county, with businesses locating wherever they feel they have the highest potential to grow.

Stage 1: Ideation. R&D will radiate outwards from central Oxfordshire, taking advantage of the Universities, other research and professional assets.

Stage 2: Innovation corridor. This will take place in growing clusters for testing and developing new businesses across the region. These are primarily located within the existing innovation corridor which extends from Begbroke in the North to Harwell in the South and beyond.

Stage 3: Commercialisation region. A wide reaching commercialisation area that extends to the whole of Oxfordshire acknowledging that business of different scales will contribute to growth from across the region, the Oxford - Cambridge Arc and the UK economy. This recognises the option that not all of this growth needs to be captured within the boundaries of the county.

The spatial concept is based on encouraging commercial graduation of knowledge assets in fit-for-purpose locations. It builds on key concepts from building an innovation ecosystem, particularly the creation of keystone assets. There will be emphasis on:

- Creating a **high-value ecosystem of economic hubs** that link science, innovation and knowledge
- Providing **multi-level connectivity** i.e. local infrastructure, strategic and national linkages and global connections
- Developing **living lab(s)** offering new lifestyle propositions for talent and demonstration of technologies such as AV/AI, distributed energy and e-mobility

5.3 THE SPATIAL VISION: A NETWORK OF CENTRES

Taking into account spatial-economic analysis, the figure below illustrates the preferred spatial pattern of growth that should take place over the next decades: As introduced on the previous page, it is comprised of three areas which cover the business lifecycle for start-ups within Oxfordshire (ideation cluster, innovation corridor and commercialisation zone). These zones show a concentration of innovation down the existing innovation spine from Begbroke to Harwell and Culham, and an expansion of commercial activity within the North of the region, expanding out to the Oxford – Cambridge Arc. Living laboratories are placed in and amongst the existing science parks providing an opportunity for start-ups to test their innovations in a live context. The numbers correspond to sites of special interested, listed on the next page.

The following pages detail how sites across the business lifecycle will be spatial distributed as a network of 25 centres.

It will explain the vision for transport connectivity between the sites, and it demonstrate how living labs will be integrated into the vision.

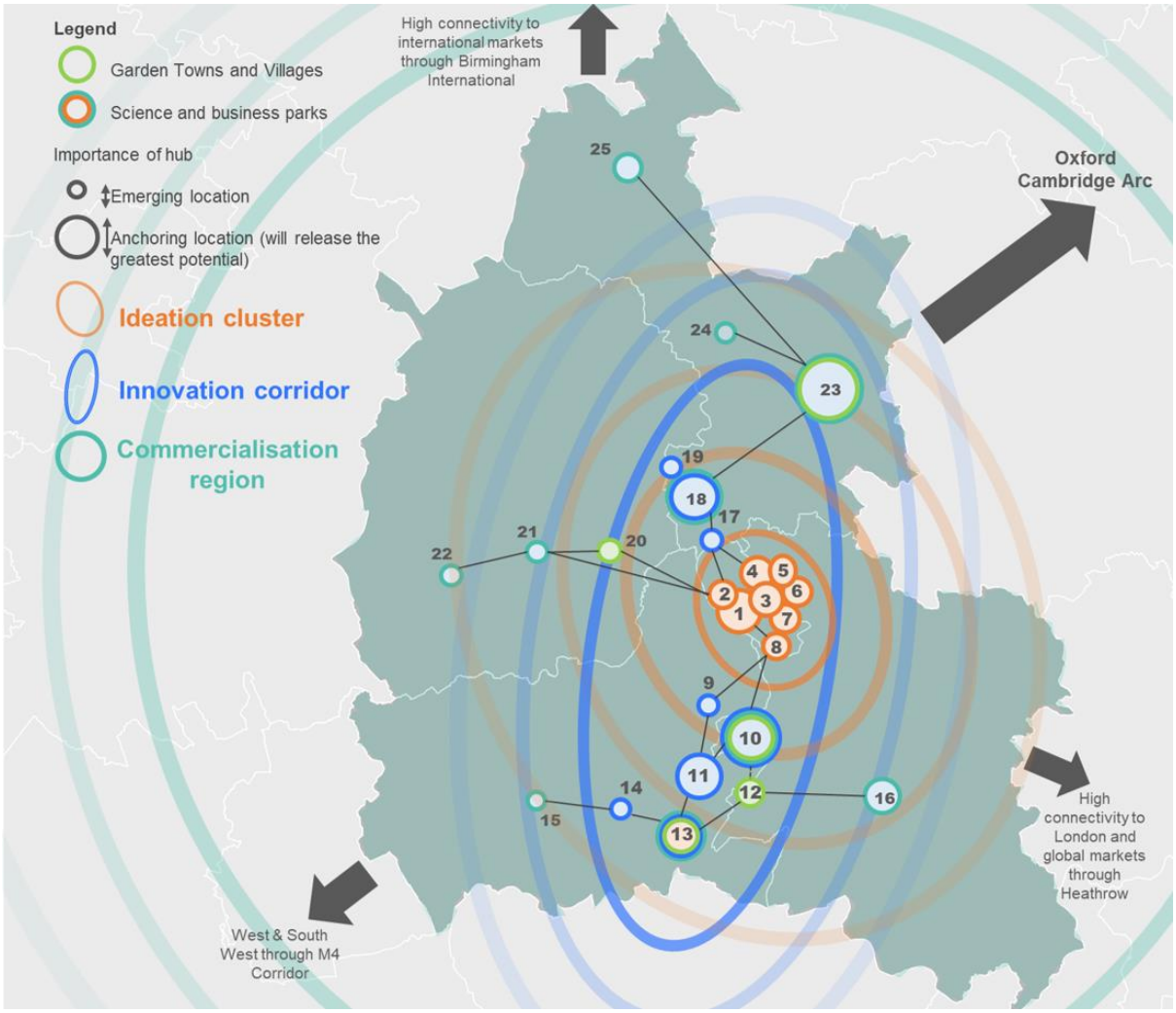


Figure 5-3 Key locations in the innovation ecosystem

Key locations for the Oxfordshire Innovation Ecosystem

1. **Oxpens** - is one of the most significant development opportunities within Oxford city centre. This site will see the creation of up to 500 homes plus offices, academic buildings and commercial space.
2. **Osney Meads Innovation Quarter** - a new knowledge park or innovation district is proposed proving greater opportunities for employment and attract investment and stimulate growth.
3. **Oxford University** - a world-leading University which will be increasingly important for ideation and innovation.
4. **Oxford Centre for Innovation** – an innovation centre accommodating start-up and growing companies in the science and technology sector.
5. **Oxford Brookes University** – a leading University with international reputation for teaching excellence and innovation.
6. **The Hospital Quarter in Headington** - a potential science and technology campus that could help to unlock housing, business growth and innovation.
7. **Oxford Business Park** – a business park with 69 businesses on site, will be a key site for future growth.

8. **Oxford Science Park** – a science and technology park located on the southern edge of the city of Oxford.
9. **Quadrant, Abingdon Science Park** – a science and business park, allowing for a range of occupational uses, including light assembly, R&D/lab space and office uses.
10. **Culham Science Centre** – through additional development could help to unlock housing, business growth and innovation at a faster scale than ever before.
11. **Milton Park** - a globally recognised science and business park with future expansion capacity.
12. **Didcot Garden Town** - new development will create some 15,000 new homes and 20,000 high-tech jobs over the next 20 years.
13. **Harwell Science and Innovation Campus** - through additional development could help to unlock housing, business growth and innovation at a faster scale than ever before.
14. **Grove Technology Park** - supports start up, growing and large business with serviced offices, whole buildings and bespoke commercial buildings.
15. **Defence Academy, Shrivenham** – through development could provide increased employment and housing sites.
16. **Howbery Business Park** - a thriving business community and home to a wide range of organisations. There are potential commercial development opportunities in the Business Park
17. **Oxford North** - planned to be developed as a mixed use innovation district providing around 90,000 sq.m of business premises, including innovation, incubator and co-working spaces, plus housing and ancillary uses.
18. **Begbroke Science Park and Innovation Centre** - focused mainly around life sciences and hi-tech applications. It will be important to build the innovation to the north of Oxford.
19. **Oxford Technology Park** - a major new science and technology park poised to provide much needed flexible R&D space in the heart of Oxfordshire's A34.
20. **Cotswold Garden Town** - will make a major contribution towards providing much-needed homes and jobs in a high quality living environment. It will also unlock funds to improve infrastructure and boost the case for improvements to local transport links, including upgrades to the A40.
21. **Witney Business & Innovation Centre** - flexible and affordable office space for start-ups and growing local businesses.
22. **Carterton & RAF Brize Norton** - through additional development could provide increased employment and housing sites.
23. **Bicester Garden Town** - currently focusing on the automotive, energy and renewables industry, provides the space and excellent connectivity to support scaling innovative entrepreneurial ventures.
24. **Heyford Park** - a growing business location that accommodates the Cherwell Innovation Centre.
25. **Banbury** - a major logistics hub that will support exporting opportunities to the Growth Corridor or elsewhere in the UK.

1. Ideation cluster

The central innovation cluster is the heartbeat of the Oxfordshire Innovation Ecosystem. It groups companies at the **ideation stage of business maturity**, which benefit from close proximity to world-class research and knowledge assets.

Concentrating enterprise activity within **Oxpens** and **Osney Meads Innovation Quarter** will create a flourishing and vibrant zone fit for the future talented workforce. Developing these areas will bring numerous incentives for investment in the upgrading of **Oxford railway station** as an iconic gateway.

A **Global Health & Life Sciences Quarter** will promote a more collaborative environment that will harness the power of innovation to help meet the needs of an ageing society; by bringing together young, growing life science companies with academia and the NHS. This will build upon the clinical excellence already seen within Oxfordshire.

Ideation is just one component of this area and other complementary activities will take place there. The development of the **Global Central Business District** will create a flourishing and attractive zone for large Fortune 500 companies. Our proposal is that it will be situated close to Oxford City and Oxford train station benefiting from excellent transport links to London. The global innovation zone provides an opportunity, creating links to global supply chains and provide expertise to smaller innovative firms already existing within the area.

2. Innovation corridor

This cluster will benefit from a concentration of knowledge and research across various centres spanning the zone from Begbroke Science Park to the north of the city centre, down to Culham Science Park and Harwell Science and Innovation Campus.

This will include intensification at existing science and business parks with capacity: **Harwell Science & Innovation Campus**, a thriving science and technology campus; **Culham Science Park**, a centre for fusion research; and **Begbroke Science Park** which has over 60 organisations working at the site focused mainly around life sciences and hi-technological applications.

Oxfordshire's sectoral expertise includes **fourth industrial revolution technologies: Digital Health, Space led data applications, Autonomous Vehicles, and Quantum Computers** as well as SIA+ sectors. Concentrating the development of such sector within a small geographical location will lead to greater knowledge sharing, and support between organisations, consequently leading to the collision and creation of new technologies and industries.

3. Commercialisation region

The commercialisation region will house those businesses which are looking to take their innovations to market and are looking for more space to undertake further prototyping and testing, alongside some commercial activity. The majority of these sites are situated to the West and North of the City Centre within the districts of West Oxfordshire and Cherwell. There will also be sites within the Vale of White Horse and South Oxfordshire that will also undertake some commercial activity. This will create linkages to areas that have **capacity for advanced facilities** with **more space** and relatively **more affordable land**. These sites should provide opportunity for small enterprises to growth and develop, while still maintaining connections with their innovation centres for business support where necessary.

Key locations include **Banbury** as a major logistics hub that will support exporting opportunities to the Growth Corridor or elsewhere in the UK. **Bicester** which currently focus on the automotive, energy and renewables industry provides the space and excellent connectivity to support scaling innovative entrepreneurial ventures.

Also within Cherwell is the **Cherwell Innovation Centre** located in the Upper Heyford area on the site of the former RAF Heyford. It forms part of **Heyford Park,** a growing business location.

All three sites have excellent connections to the Midlands and Growth Corridor, connecting to wider businesses within the UK. Within West Oxfordshire, **Carterton, Witney and Eynsham** provide further space for businesses to growth and expand.

Commercialisation will not be exclusively limited to the North of Oxfordshire with **Harwell and Culham** providing key sites for business development in the South of Oxfordshire. These areas have excellent links to the Thames Valley, London and wider global networks.

5.4 THE SPATIAL VISION: A LIVING LABORATORY

Oxfordshire will develop as a living laboratory – a testbed for innovation to solve the UK's Grand Challenges and accelerate the adoption and accessibility of innovation across the ecosystem. This will include pioneering places that future proofs communities by preparing them for technological and environmental change including the advent of connected and autonomous travel, all electric energy, smart homes and sustainable living.

The concept of a Living Lab

The below definition of Living Labs is the definition used by the European Network of Living Labs – the international federation of benchmarked Living Labs in Europe and worldwide:[52]

"Living Labs are defined as user-centred, open innovation ecosystems based on systematic user co-creation approach, integrating research and innovation processes in real life communities and settings.

Living Labs are both practice-driven organisations that facilitate and foster open, collaborative innovation, as well as real-life environments or arenas where both open innovation and user innovation processes can be studied and subject to experiments and where new solutions are developed.

Living Labs operate as intermediaries among citizens, research organisations, companies, cities and regions for joint value co-creation, rapid prototyping or validation to scale up innovation and businesses. Living Labs have common elements but multiple different implementations."

A Living Lab provides a real-life environment where systems, services and processes can be safely developed at speed, evaluated, de-risked and integrated with the needs and ambitions of the local community. Solutions are demonstrated as fit-for-purpose, investable and translatable to ecosystems (e.g. transport, housing, health, energy, industry) nationally and internationally, including evidencing user-led development and public acceptance.

Living Labs attract industry because they provide a commercial advantage to participants. They do this through accelerated and early market entrance, which returns value to the local and

[52] Enoll, retrieved from https://enoll.org/about-us/

national economy through high value job creation, and ideally long term production or service provision based in the UK.

A Living Lab involves a multidisciplinary, multi-sector team working together to explore opportunities for:

- **Co-creation of solutions** by bringing together technology push and market-pull factors across a diverse range of viewpoints, constraints and knowledge levels so as to sustain the exploration of new scenarios, concepts and related potential products and solutions.
- **Exploration** by engaging all stakeholders, especially user communities, at an earlier stage of the co-creation process to discover emerging scenarios, usages, commercial models and behaviours through live scenarios in real or virtual environments.
- **Experimentation** that implements appropriate technological artefacts in vivo to generate live scenarios involving large number of users whilst, in parallel, collecting data for analysis.
- **Evaluation** that assesses innovative concepts as well as related technological artefacts in real life situations through various dimensions such as socio-ergonomic, socio-cognitive and socio-economic aspects. It is the observation of what happens when technology confronts user value models that roots a Living Lab in experiential rather than experimental learning.

Putting people at the centre of future service and technology adoption across Oxfordshire

We will build ‘connected communities’ that use the best of these new technologies for the benefit of different types and sizes of community in different places. A Living Laboratory is a real place involving real people going about their normal lives using and evaluating the latest technology enabled products and services at a scale which demonstrates proof of concept and scalability for governments, multi-national industries and investors.

This is important as we see the new technologies of the twenty first century increasingly changing the way we live and shaping our futures. Living Labs are an opportunity to shape communities that use these technologies to enhance wellbeing and quality of life. We are already seeing opportunities arise, especially as technologies begin to converge. For example, we can see overlaps between digital health initiatives and new mobility solutions for people and goods that draw on data measured from space and collected in our homes. Clean energy production and distribution, emissions and waste management could become something that will involve national and off-grid networks, potentially with different infrastructure requirements and ownership models.

These convergences have significant potential to shape our communities, improving quality of life and standards of living whilst also addressing critical challenges – such as the UK’s Grand Challenges of clean growth, mobility, ageing society and AI and data. This plays to our regional strength – global leadership in science-based innovation and research and development.

Living Labs involve the testing and evaluation of these products and solutions, and so therefore depend on social as well as physical sciences to collect data and undertake rational analysis. Generating and understanding data is critical to demonstrate proof of concept and the scalability of solutions to governments, industry and investors. It presents an opportunity beyond purely innovation to engineer tradeable products and services that move businesses through the business lifecycle from ideation, through to product development and testing and finally to commercialisation and value capture.

The key building blocks for Oxfordshire's Living Lab

The key building blocks for world leading Living Labs already exist in Oxfordshire and the Oxfordshire Industrial Strategy will bring them together to deliver economic benefit and improved services for local communities across the county, which will be transferable to the rest of the UK and internationally:

- A community of senior leaders across industry, academia and local public services who are recognised as market leaders in complementary disciplines across energy, healthcare and life sciences, engineering, mobility, data and quantum computing united by the opportunity that Living Labs present for the UK both to resolve UK challenges and generate knowledge to build export markets.
- Fundamental and translational research in the big facilities at Churchill, Harwell and Culham that underpins the UK national effort across the physical sciences and engineering in both academia and industry. 20% of the programs at Diamond and ISIS focus on energy research and development and the UKAEA was established in 1954 to focus on long term energy solutions with its present focus on fusion and robotics.
- Accelerated product development at local companies and start-ups in the Oxford, Harwell, Milton and Culham Science Parks across critical sectors, together with strategic partnerships with major companies including Siemens, Bosch, EDF Energy, Immunocore and BMW.
- The presence of future-ready innovation test beds pioneering new solutions.
- Significant opportunities to accelerate public – private investment in world leading R&D and supporting wider UK ambitions to increase R&D to 2.4% of national GDP.
- Planned development of 100,000 new homes under the Oxfordshire Housing & Growth Deal including new garden towns (Didcot, Bicester), garden village (West Oxfordshire) and healthy new town (Bicester) and major new settlements at Culham and Yarnton.
- Integration with the planned Oxford – Cambridge Arc and transport systems.

Partners in Oxfordshire already work together, across local authorities, universities and local businesses, to deliver innovative projects to the region that are demonstrate the living lab concept – demonstrated in the following case studies:

CASE STUDY: Smart Oxford

Smart Oxford is a strategic program to develop the shared vision of Oxford as a Smart City, embedding innovations into the city ecosystem and creating a test-bed for city innovation that can be shared with the broader world. It seeks to create an open environment for anyone to contribute in co-creating in a sustainable and affordable place amidst the challenging and growing Oxford landscape. Current board members include local business and world-leading research organisations. A number of projects have been facilitated through Smart Oxford, ranging from Smart Heritage City to the Playable City commissions.

Innovative projects to date have worked with neighbourhoods on mobility and wellbeing; through the innovative use of big data, social media and other data sources; with work to advance the introduction of autonomous vehicles.

CASE STUDY: The MobOx Foundation Living Laboratory

Oxfordshire County Council, together with academia (Oxford University, Oxford Brookes University) and industry (Zeta Automotive, StreetDrone, Preston Racing), have established the Mobility Oxford Foundation. This is a Community Interest Company set up to lead on innovation in all mobility-related issues in Oxfordshire. Its aim is to support, incubate and develop new ideas and new opportunities, to solve the problems of urban transport in Oxford and elsewhere, with Oxford and wider Oxfordshire to act as a supporting testing facility.

The MobOx Foundation is working with partners to create a living laboratory in Oxford to assess, validate and prove the business case of a variety of innovative transport solutions. The objective is to create an ecosystem and proving ground that will allow all mobility stakeholders to experiment with and prove out new technology concepts, business models and identify future opportunities for the development of a truly integrated transport system all within a controlled environment. It will improve the user experience of multi-modal transportation, increasing transport density, efficiency and cleanliness.

CASE STUDY: Autonomous vehicles test environment

Oxfordshire is world-leading in connected and autonomous technology, and in real world test environments for autonomous vehicles – this is something we will build on in the Oxfordshire Industrial Strategy. A number of projects are already being delivered around Oxfordshire that use the living lab approach to test and evaluate autonomous vehicles in real-life environments.

- **RACE at Culham** operates as one of the UK's only semi-controlled test beds allowing the development of driverless cars, sensor technology and intelligent traffic systems in a safe environment. RACE is working with vehicle testing specialists Millbrook Group to form the Millbrook-Culham Test and Evaluation Environment. This is creating a series o tracks to mimic a range of real-life driving environments where automated vehicles can be put through their paces before going on to public roads.
- **DRIVEN**: DRIVEN brings together autonomy specialists, world-class innovators, key enablers, disseminators and transport experts. The DRIVEN consortium is an ambitious project that will see a fleet of fully autonomous vehicles being deployed in urban areas and on motorways, culminating in an end-to-end journey from London to Oxford. These vehicles will be operating at Level 4 autonomy – meaning they have the capability of performing all safety-critical driving functions and monitoring roadway conditions for an entire trip, with zero-passenger occupancy. No connected and autonomous vehicle trial at this level of complexity and integration has ever been attempted anywhere in the world.

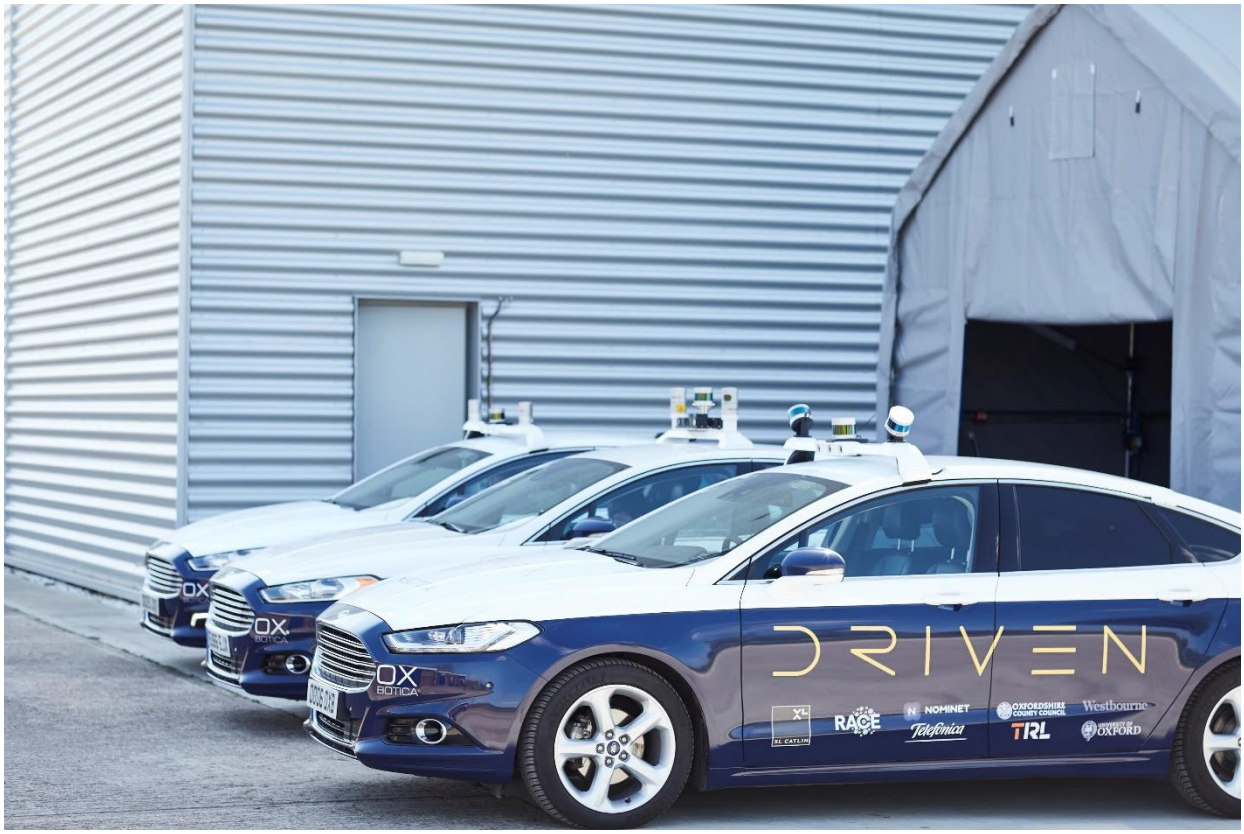


Figure 5-4 DRIVEN

5.5 SPATIAL VISION: MULTI-LEVEL PHYSICAL AND DIGITAL CONNECTIVITY

Oxfordshire has set out its ambition to become a top three global innovation ecosystem by 2040. As highlighted throughout both baseline and future state economic review, Oxfordshire (and the rest of the world) is being shaped by new technologies of the twenty first century. These include highly disruptive technologies such as AI, robotics, nanotechnology, blockchain, quantum computing, Internet of Things, 3D printing and autonomous vehicles. These technologies represent a significant opportunity for growth and wealth creation, as well as new ways to shape communities that improve health and wellbeing. They have the capacity to change the ways we build houses, provide education, healthcare, mobility and public services and deliver sustainable and clean economic growth.

This is a significant opportunity for growth in Oxfordshire – but only if we have the right physical and digital infrastructure in place to make it possible. Physical and digital infrastructure improvements should also look to incorporate these technologies, integrating them into the way that people live and work. This will also be critical if Oxfordshire is to rollout the Living Lab concept, testing these new technologies and innovations across Oxfordshire's communities.

Our spatial vision therefore focuses on critical infrastructure enablers that are necessary to improve connectivity across key growth locations in Oxfordshire and allow Oxfordshire's businesses and residents to embrace these new technologies of the twenty first century. Reliable infrastructure is critical for creating healthy, connected communities that attract and retain the talent our innovation ecosystem depends on. Connectivity is closely linked with productivity, and is also critical for attracting businesses and securing investor confidence. Our infrastructure ambitions align to the Oxfordshire Infrastructure Strategy, an evolving infrastructure list that

reflects the demands from growth in the county and informs and is informed by the JSSSP and Local Transport Plans.

We have divided this section of the spatial vision into a number of sections:

- Physical infrastructure:
    - Smart Corridors
    - Mobility hubs and rapid transit
    - Inclusive connectivity
- Digital infrastructure
- Energy infrastructure
- Major new developments

PHYSICAL INFRASTRUCTURE

As set out in the Baseline Economic Review, physical infrastructure across Oxfordshire needs to be improved. As part of the spatial vision, Oxfordshire will implement key infrastructure projects that align to the Oxfordshire Infrastructure Strategy – see figure for more detail.

Smart Corridors

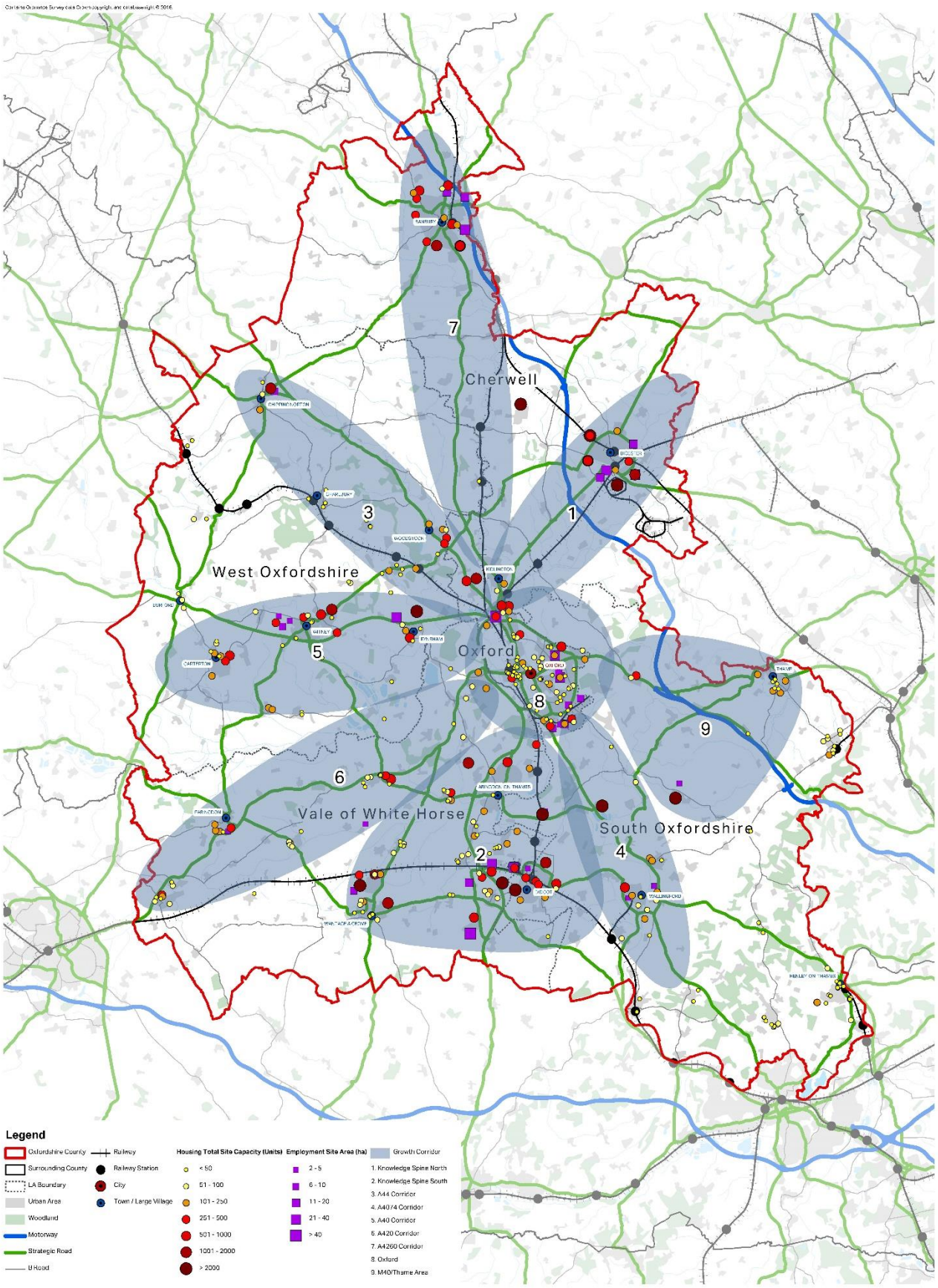
Oxfordshire will have a network of Smart Corridors that prioritise walking, cycling and public transport, whilst also making the most of available technology. A network of Smart Corridors will provide a first class journey experience with strong focus on quality, reliability and integration between different transport options.

We will adopt measures to manage traffic levels to reduce the impact of congestion and enable Smart Corridors to use road-space more efficiently. Excellent urban design, emphasis on place-making, and measures to improve air quality will create well-connected, healthy communities and improve quality of life. Existing highways will be comprehensively redesigned to deliver Smart Corridor features across whole corridors. Proposals for these will need to flexible enough to respond to geography, demands of the corridor and ongoing changes in technologies and behaviours.

Mobility hubs and rapid transit

All urban and rural rail stations and key bus interchanges will become adaptable mobility hubs. They will have upgraded facilities and high quality digital connectivity, will allow for increased passengers and enable integrated services between different transport options. Part of this will include major upgrades to Oxford Station to increase capacity and act as an international gateway and first class mobility hub.

Figure 5-5 Identified growth sites in the Oxfordshire Infrastructure Strategy



Identified Growth Sites

Oxfordshire Infrastructure Strategy

AECOM

For example, Oxford Station will be upgraded to act as an international gateway, delivering increased capacity and becoming a first class facility in its own right. It will be a key mobility hub that supports local Oxford urban investment.

We will also open the Oxfordshire Rapid Transit Network. This will connect development sites across the ecosystem and provide a cheaper, faster, more reliable travel option than the private car for the majority of journeys in the ecosystem, and will be delivered in conjunction with the Smart Corridors concept.

Inclusive connectivity

We will build on world-leading work in fields such as autonomous vehicles, data, Mobility as a Service and Demand Responsive Transport to develop a, connected, integrated transport service that provides seamless travel and utilises digital journey planning, ticketing and real-time network management that is customer-oriented. We will use our public sector street assets and invest in digital infrastructure to support the roll out of Smart City Internet of Things and 5G networks across the county. This will provide the digital foundation to support the Living Laboratory approach and deliver an uplift in services to communities across Oxfordshire.

DIGITAL INFRASTRUCTURE

Oxfordshire has a vision to be a world class region in the heart of England with integrated transport, communications fit for the digital age, aligned strategies for housing, education, healthcare, public sector service delivery, and sustainable economic growth. This supports the UK government's ambitious digital infrastructure targets e.g. 15 million premises will be connected to full fibre by 2025. A virtual presence is a key element of this vision and within the context of the Oxfordshire Industrial Strategy, will be essential to enhance connectivity between sites whilst preserving the natural environment. We will focus on improving digital infrastructure on two level:

- **Digitalisation between businesses**: Currently over 50% of premises have access to superfast broadband, however only 7% have full fibre connectivity which is well behind other world leading innovation ecosystems. SMEs within the innovation sector rely on this connectivity, and growth within the high-tech and biosciences sectors will be constrained if they cannot access affordable full fibre. Therefore, Oxfordshire should spread the implementation of full fibre technology. The aim should be to have 100% coverage, allowing collaboration between science parks and to the global innovation network. An alternative and complimentary strategy to this would be to pioneer the implementation of a 5G network, allowing businesses to stay connected in remote areas and on the move.
- **Digitalisation for passengers**: This feeds into the physical infrastructure 'inclusive connectivity' vision. Digital innovation will also focus on improving connectivity for residents commuting within and to Oxfordshire. A digital route planner would enable a seamless end to end journey for those using the integrated public transport system.

ENERGY

If Oxfordshire is to grow and expand to a £46 billion economy, it will be essential to provide additional capacity in the energy network to allow businesses to grow and expand. The region has a vision to be at the forefront of energy innovation to foster clean growth. Therefore, this vision should be used to facilitate growth for the Oxfordshire Industrial Strategy.

Additional clean energy infrastructure will need to be provided to increase the electricity grid capacity accounting for the increase in industrial and commercial activity and associated housing. This must be provided at low cost, accessible to both science and research and industrial sites. In order to meet this scale of demand, electricity and heat energy will need to be provided by multiple sources. For example, by 2030, Oxfordshire aim to have at least 56% of electricity demand and 40% of heat requirements met by renewable energy.

Secondarily, in order to meet the growth targets but also achieve carbon reduction targets efforts should be made to reduce the demand for energy within existing and future developments to ease the pressure on the renewables-based energy system.

In order to achieve the vision and deliver clean energy for the Oxfordshire Industrial Strategy growth plans, the existing Oxfordshire networks should be utilised. For example, existing collaborations and partnerships should be used to test and experiment with clean energy initiatives within proposed living labs.

MAJOR NEW DEVELOPMENTS

Creating the right places will attract talent and provide the skills to accelerate growth within the county. This will be achieved through a number of key proposals which will develop **nodes of integrated innovation, business and residential sites.**

Garden Towns and Villages prioritise well-planned and well-designed communities. In Oxfordshire, three locations have been identified for additional housing, jobs and supporting infrastructure, which include:

- **Didcot Garden Town** - New development will create some 15,000 new homes, 20,000 high-tech jobs over the next 20 years.
- **Bicester Garden Town** - New development will create some 13,000 new homes and 18,500 new jobs focused on high value, high-technology industry sectors.
- **Oxfordshire Cotswold Garden Village** - New development will create 2,250 homes and improve local transport links e.g. upgrades to the A40 by 2031.

Expansion of existing science parks: This will include intensification at existing science and business parks with capacity: **Harwell Science & Innovation Campus**, a thriving science and technology campus; and **Culham Science Park**, a centre for fusion research. These sites have also been identified for additional housing capacity.

Mixed-use sites that will provide new housing and commercial development to support Oxfordshire's science and technology activities include:

- **Oxford North (previously Northern Gateway)** - Located on the northern edge of the city, this area is planned to be developed as a mixed use innovation district providing around 90,000 sq.m of business premises, including innovation, incubator and co-working spaces, plus housing and ancillary uses. The 44 ha employment site north of Wolvercote will see the creation of some 480 homes, a 90,000 sq.m commercial innovation quarter and 180 hotel bed spaces
- **Oxpens** – The area is one of the most significant development opportunities within Oxford city centre. Located in the Oxford West End, close to the Railway Station, the University and the Westgate Shopping Centre the site has potential to make a valuable contribution to the life and economy of the City through the delivery of new housing,

flexible office space, a hotel, local facilities and public open space. This site will see the creation of up to 500 homes plus offices, academic buildings and commercial space.

- **Osney Mead Innovation Quarter** - This proposed development will be located on the old Osney Mead Industrial Estate, which was created in the mid-20th century to relocate industries from elsewhere in Oxford city. The site is well located, being in close proximity to the city centre, railway station and the road, cycle and pedestrian network. A new knowledge park or innovation district is proposed which will provide greater opportunities for employment and attract investment and stimulate growth and regeneration in Oxford. The site will see the creation of 600 homes by 2025 for key university staff and students, supporting the expansion of Oxford University research and development activity through postgraduates and early career post-doctoral researchers.

To allow these developments to be realised it will be critical for the right land to be released. Oxfordshire should work with private landowners and the Government to accelerate the decommissioning programme for key sites and explore options for time-limited planning flexibilities to fast-track the delivery of the new development schemes

NEXT STEPS

Throughout this report, we have focused on how the world and Oxfordshire is going to change between now and 2040, setting out our vision for how Oxfordshire can embrace the new technologies of the twenty first century to become a top three global innovation ecosystem. We have specifically sought to examine how our local economy could develop and the spatial implications of pursuing an ambitious growth strategy.

This report has demonstrated the global significance of Oxfordshire's industries and assets, and the potential for growth. Oxfordshire has the potential to be world-leading, and push the UK to the forefront of innovation in new industries and technologies with markets that expect rapid growth. If we initiate a step-change in growth to achieve our vision, we have forecast that we can double the Oxfordshire economy by 2040 to be worth £46 billion. This will stimulate transformative growth in the regional economy, as well as generate additional growth for the rest of the UK - both for the cornerstone businesses that provide essential services and supply chains to these industries, and for other regions across the UK. Our analysis shows that for every £1 invested in Oxfordshire, Oxfordshire will deliver a multiplier effect of £4 for the UK economy – this is an unprecedented scale of return that only a highly innovative economy like Oxfordshire can deliver.

This report will be followed by the Oxfordshire Industrial Strategy and Investment Prospectus. These will set out a targeted growth strategy for Oxfordshire that will deliver benefit for Oxfordshire's communities, businesses and for the UK.

6. APPENDIX A: INDICATORS FOR DEMAND MAPPING

Layer	Indicator	Description of indicator	Source	Urban development "accelerator"	Urban development "decelerator"
Current urban structure	Population Density	Population density is calculated as the population estimate of each MSOA divided by its land area in square kilometers.	Office for National Statistics (2016)		
	Building Density	Building density is calculated as the total number of buildings within each MSOA divided by its land area in square kilometers.	Ordnance Survey data (2011)		
	Economic Density	For a given MSOA in England, this is a weighted average of aggregated firm revenues in each other MSOA weighted by their road travel time from the given MSOA.	PwC Data (2013)		
	Housing Affordability	Affordability ratios calculated by dividing house prices by gross annual workplace-based earnings. Based on the median and lower quartiles of both house prices and earnings in England and Wales.	Office for National Statistics (2016)		
Physical constraints	Area of Outstanding Natural Beauty (AONB)	ONBs are designated areas where protection is afforded to protect and manage the areas for visitors and local residents.	Natural England Open Data (2018)		
	Green Belt	Polygon dataset (in WGS84 projection) showing each English local authority's green belt land.	English Local Authority Green belt dataset (2018)		
	Special Areas of Conservation	Special Area of Conservation (SAC) is the land designated under Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora.	Natural England Open Data (2018)		
	Parks and Gardens (Historic Conservation sites)	The Historic England 'Register of Historic Parks and Gardens of special historic interest in England', established in 1983, currently identifies over 1,600 sites assessed to be of particular significance.	Historic England		
	Sites of Special Scientific Interest	A Site of Special Scientific Interest (SSSI) is the land notified as an SSSI under the Wildlife and Countryside Act (1981), as amended	Natural England Open Data (2018)		
	National Nature Reserves	A National Nature Reserve (NNR) is the land declared under the National Parks and Access to the Countryside Act 1949 or Wildlife and Countryside Act (1981) as amended	Natural England Open Data (2018)		
Future urban and economic structure	GVA	Gross value added to the economy - the income generated by workers and companies in the creation of goods and services.	PwC Data (2018)		
	Productivity	This is simply the GVA generated per job.	PwC Data (2018)		
	Jobs	The total number of jobs per MSOA.	PwC Data (2018)		
	Planned infrastructure	Planned future infrastructure projects within Oxfordshire including housing, transport networks and business/science parks.	Various policy and planning documents		

7. APPENDIX B: EXPLANATION OF INVESTMENT MULTIPLIERS (PLACEHOLDER)

8. APPENDIX C: POLICY AND EVIDENCE GUIDE (PLACEHOLDER)